SAE journal

MAY 1957

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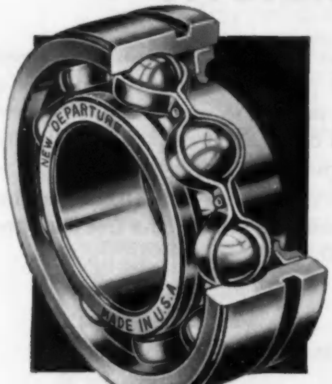
FACTS

about

NEW DEPARTURE BALL BEARINGS

EASIEST HAULING LEAST MAINTENANCE



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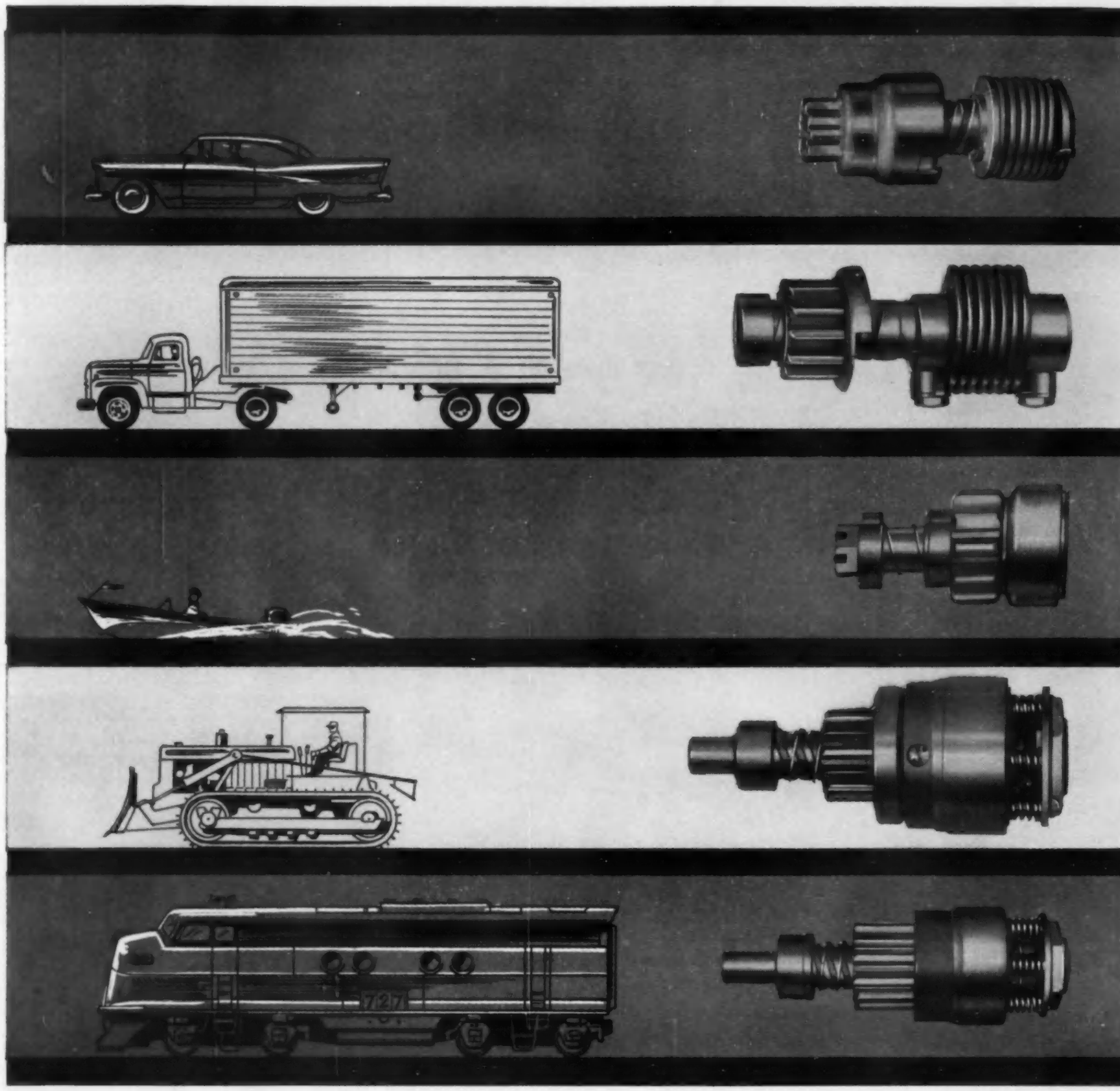

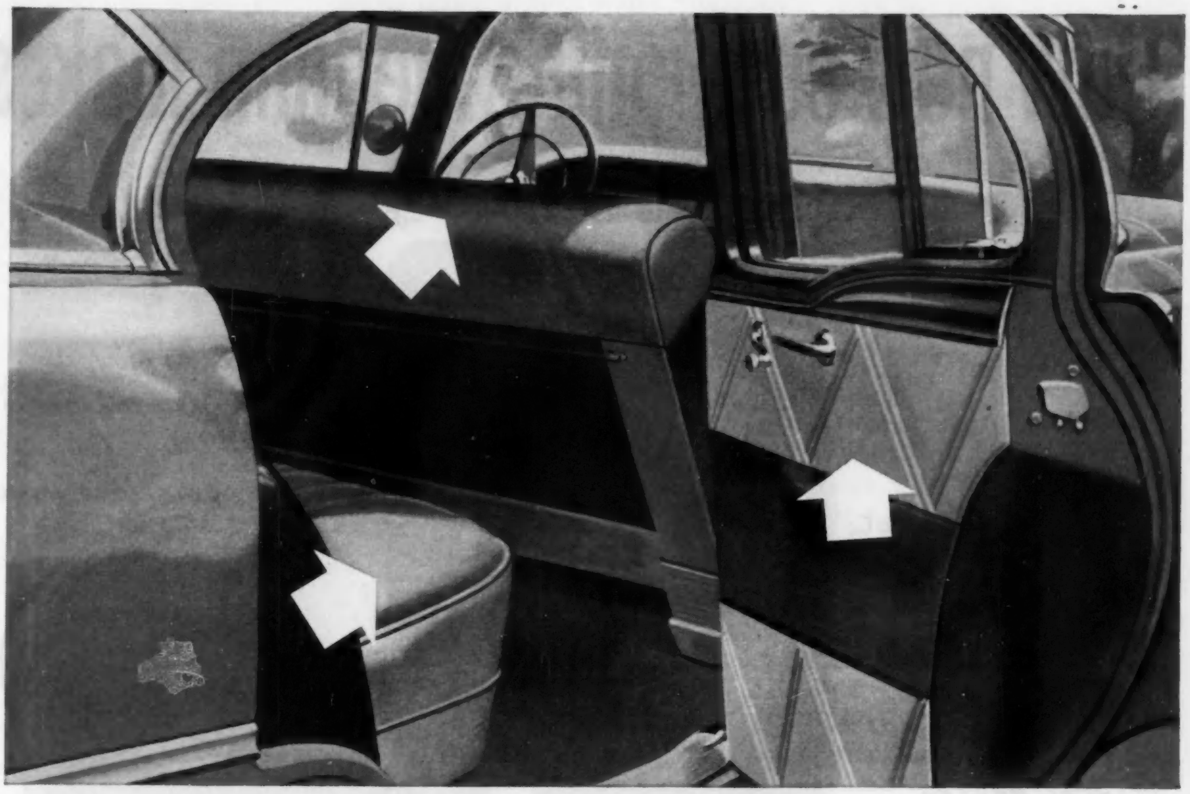

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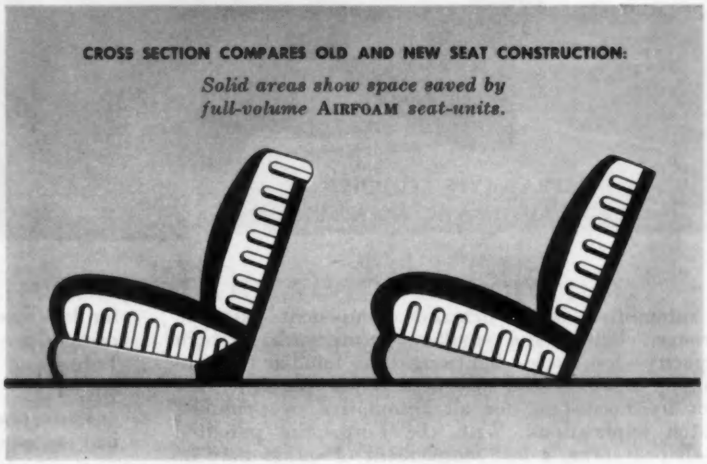

CROSS SECTION COMPARES OLD AND NEW SEAT CONSTRUCTION:

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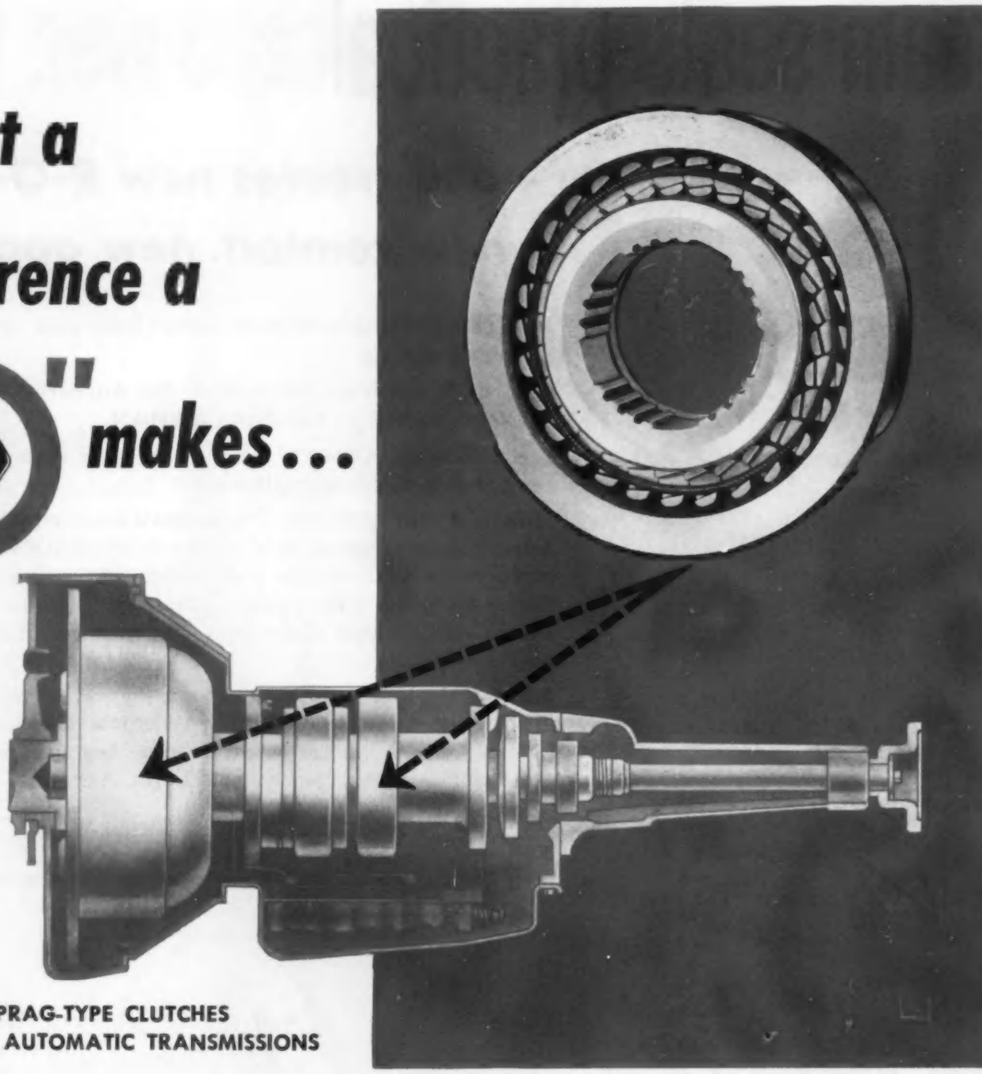

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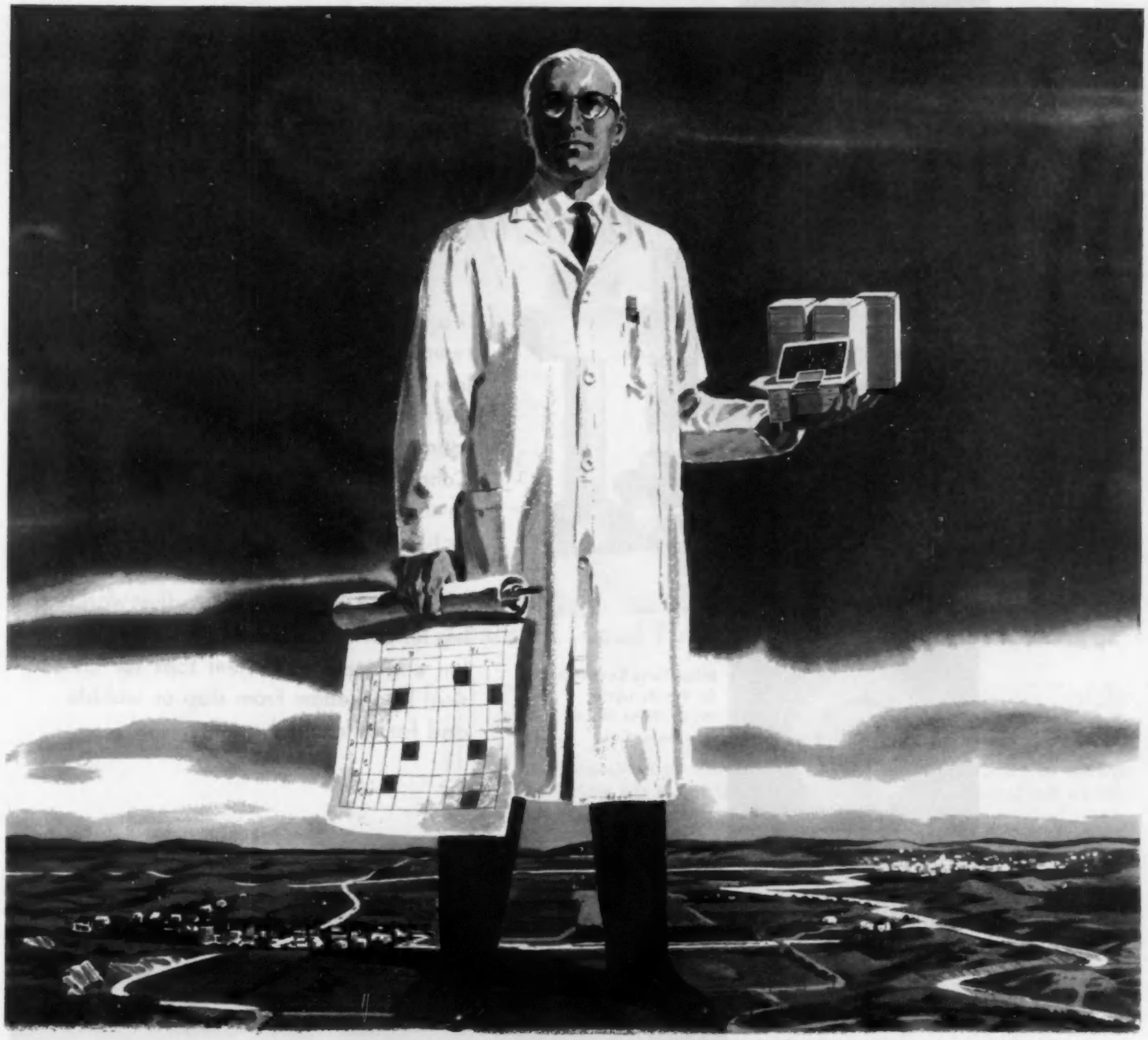


For the Sake of Argument

Leads on "Lead Time" . . .

By Norman G. Shidle

The phrase "lead time"—now a fixture in industry's vocabulary—describes something that everybody is trying to reduce on a continuing basis . . . throughout all of his activities.

Reduction comes as often from change of mental pace as from change in procedures or processes. Quicker focus on and delineation of specific problems speeds fruitful research as much as new-type test apparatus. Prompt start of problem study permits sound decisions on time. Quick thinking to immediate decision can often speed up a project's existing momentum where less agile handling would let it run down.

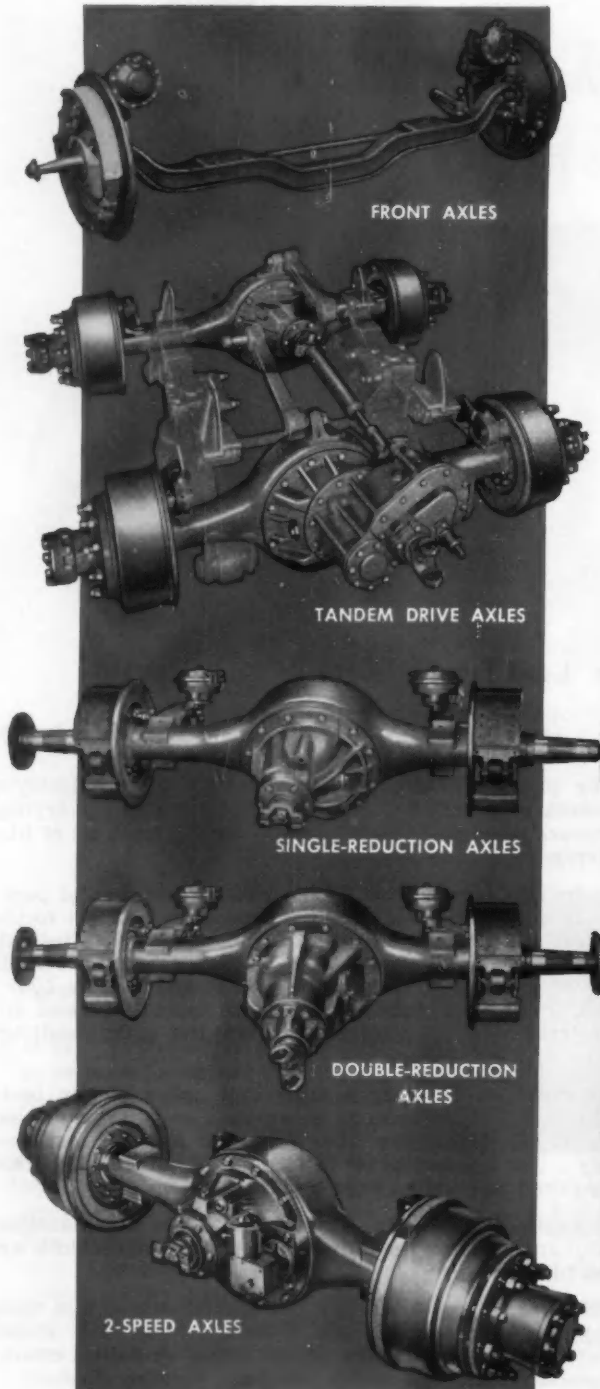
In every engineering organization, some of the best product potentials have to be grabbed and harnessed as they fly by. Otherwise, they fizzle out and are lost entirely . . . or a powerful lot of fanning of enfeebled sparks is required to revive a once-brilliant flame.

"Imagination, awareness, and courage to take sensible risks," John Warner says, "are among the ingredients we need to nurture.

"Every company or society has organizational and traditional amenities that need to be observed. But these should not be used to hide behind while we turn a crank to produce stale and stodgy results.

"They can and should be used to make the 'k' or reactivity factor of our functioning positive and supercritical. (See page 69, SAE Journal, February, 1957). Let's not worry for the moment about 'moderators' (those materials of low atomic mass which are used to slow down neutrons without capturing them) in our generation of ideas and activity.

"There exists scarcely an engineer or an engineering group which might not profit from reducing lead time all over the lot. But to do it, is likely to require a very careful inspection of ALL possibilities."



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Norman G. Shidle
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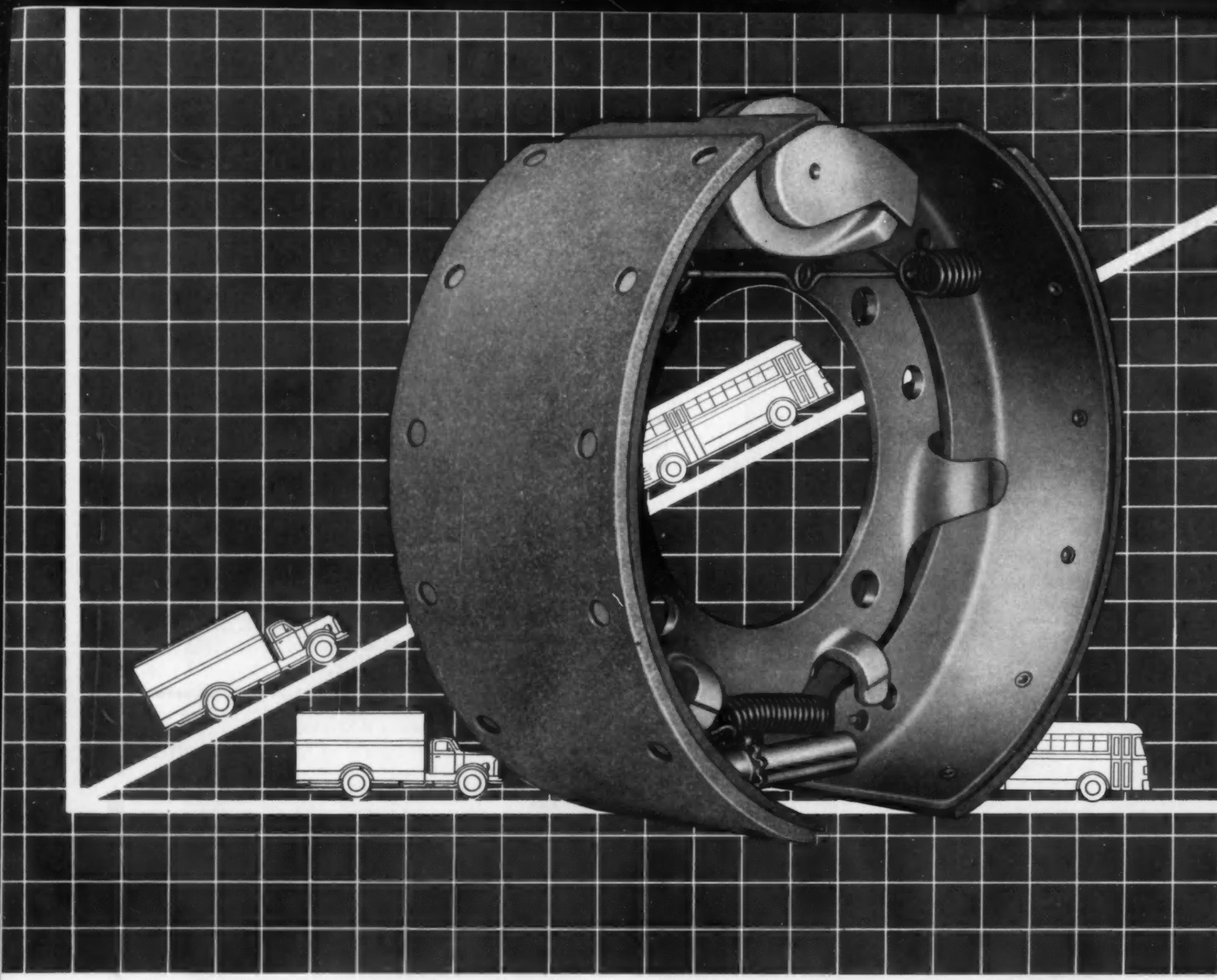


Lighter Powerplants, Transmissions Key to

Big Car Rear-Engine Designs

Based on paper by **John R. Bond**, consulting engineer

IN the final analysis, the practicality of an American-sized rear-engine design depends on what kind of fore-and-aft weight distribution can be achieved for a given number of dollars. To make feasible a rear-engined job with both American size and performance, several developments will be needed.

Much lighter powerplants will be required to make even a 40/60 weight distribution possible . . . and that is about the maximum-extreme needed to make a rear-engine mounting practical. The transmission designer will have to do his part in weight reduction, too. So will the designers of drastically overweight accessory items.

At the front, larger wheel movements will be required to keep front-end periodicity at present values. . . . And in the rear, some form of independent suspension will be mandatory. The chassis and frame problem offers no particular barriers. It is not appreciably different from that of a conventional car.

New Developments Favor Rear-Engine Car

Some relatively recent developments, however, are favorable to a rear-engined car with American size and performance.

Already, for instance, smaller and lighter electrical units, hydraulic pumps, and fuel supply systems are available, requiring only mass production to get competitive costs

The modern trend toward new and more compliable suspension systems, incorporating such devices as automatic compensation for load changes will be a big help toward more favorable weight distribution. Need for understeering front-end geometry on the rear-engine car will allow continuation of low roll centers in front. (This eases the geometry problems inherent with increased bump and rebound travels.)

Weight Distribution Basic

Every engineer knows that a safe and stable automobile can't be built with a 650-lb cast-iron engine and a 175-lb automatic transmission in the trunk. And the stern realities of cost figures preclude the immediate possibility of reducing those weights materially on a car of American size and performance.

No one would be foolish enough to say exactly how much weight can be carried by the rear wheels, and no more. But it's safe to say that a rear-weight bias of about 60% of the curb weight is very close to the maximum that can be allowed. . . . and a 45-front/55-rear distribution is a more realistic goal.

Certainly, the problem of high-speed stability must be shared by both the stylist and the suspension engineer. Even cars which are predominantly nose-heavy (and therefore presumably inherently stable) can become quite unstable when subjected to gusty cross winds This condition becomes worse as aerodynamic efficiency increases.

At any speed, a car with weight preponderance in the rear is a basic oversteerer. But with our modern knowledge of suspension design it is possible to produce a 40/60 car with a neutral steer, at least up to the point of total loss of adhesion or breakaway during cornering.

But to make a rear-engined car practical, the rear end weight MUST be less than 60% of the total under the worst conditions of loading.

Some Oversteer OK?

Some think a slight amount of oversteer, coupled with a reasonable polar moment is perhaps desir-

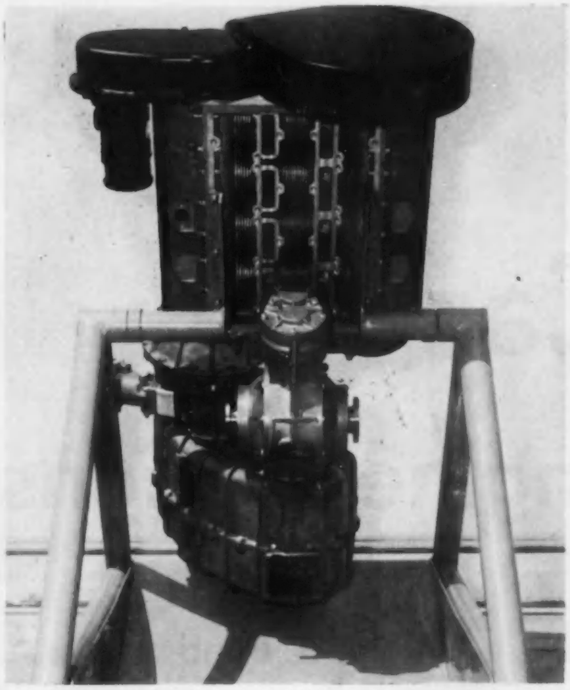


Fig. 1—This is the unique 4-cyl, double-piston Paxton powerplant, viewed from the rear but tilted upward to show the 2-stroke-cycle type cylinder ports.

able. Daimler-Benz (Mercedes), for instance, have advocated a neutral-steering vehicle at medium speeds which changes gradually to a slight oversteer at higher speeds. W. C. Done sums up by saying:

"Admittedly, a strongly oversteered car which has a low polar moment of inertia in yaw demands the highest order of driver reflex and judgment. Strongly over- or under-steered cars, however, are equally poor for maximum cornering performance. The best car . . . is one which neutrally steers up to the limit of adhesion, then lightly oversteers."

Light Engines and Transmissions

Production cost is the chief obstacle to availability of a powerplant light enough to make a large rear-engine car feasible in the near future. It is quite possible to build an engine capable of developing 300 bhp from 300 cu in. and weighing not much more than one lb per hp. But the cost of producing such an engine in either large or small quantities would be absolutely prohibitive.

Light alloys are the first recourse when weight savings are demanded. But such items as nonconventional cylinder arrangements and exhaust jet-assisted aircooling must be re-examined, too.

As engines get smaller, the specific weight tends to go up, but both the Volkswagen and the Porsche employ aircooling As a result, the complete Volkswagen engine-transmission-differential assembly weighs only 330 lb, the Porsche about the same. In the case of Volkswagen, this is 20% of the curb weight and results in an unloaded weight distribution of 43/57.

One example of what might be called "free thinking," was a flat-six rear-engined car proposed by Carl Doman several years ago, which showed how the air-pump for cooling could be eliminated. The Fletcher Aviation Co. put this idea to work with their modification of the German Porsche engine, eliminating the cooling fan. McCulloch Motors' Paxton car had an all-die-cast light-alloy 2-stroke aircooled engine with four-cylinders, eight opposed pistons, and two crankshafts. An upended photograph of this powerplant is shown in Fig. 1.

It is clear that a 6-passenger family car with a 300-bhp rear-mounted engine will be practical only if we can develop much lighter engines and transmissions . . . and it is almost certain that a 500-lb engine-transmission-differential unit will be more costly.

But it is not clear that the public will be unwilling to pay a premium for a rear-engined car. The popularity of deluxe as compared to standard models in every price class points to the fact that they will. There is every reason to believe that a full-sized rear-engined car could command a premium price. Waiting lists for the Volkswagen indicate that the American public is already "sold" on the rear-engined car.

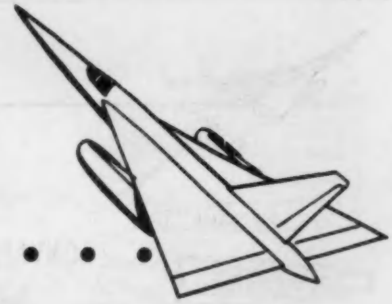
(Paper, "Rear-Engine Mounting: Its Effect on the Automobile Chassis," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

How High Can Compression Ratio Go?

▪ *The benefits of increasing compression ratio are definitely subject to the law of diminishing returns. Beyond a certain point the added cost of high-octane fuels cannot be economically justified by gains in power and efficiency. It would appear safe to predict that beyond 13/1 compression ratio nothing exists but a high fuel antiknock requirement and a host of new and complex problems.*

—James C. Hughes

Supersonic Aircraft . . . .



. . . Force Centralization of Design and Procurement Authority

Excerpts from paper by **Frank W. Davis,** Chief Engineer of Convair, a division of General Dynamics Corp.

TO achieve the degree of integrated design necessary for efficient supersonic flight requires centralized design responsibilities. The execution of such responsibility, moreover, calls for a coincident centralization of contractual authority.

Without this, design responsibility for integration can be pursued only through the medium of technical persuasion of many subsystems vendors—each under independent contract with the several cognizant government labs or agencies. Optimum technical integration of all elements of the weapon system—airframe, engines, equipment, armament, and ground support—can be achieved only when centralized authority for the entire program exists, first, within the Air Force or procuring agency, and secondly, through delegation to a single prime contractor or weapon system manager.

Responsibility with Authority

This arrangement places authority and responsibility in the same hands. It also furnishes incentives for success and punishment for failure since it eliminates any possibility of buck-passing among several agencies, each having some but not full responsibility.

The B-58 supersonic bomber was designed and built under centralized weapon system management. We believe the plane's achievements prove our contention.

The B-58 program is probably the closest to a single prime contractor arrangement of any to be found in recent U.S. history of aircraft procurement. The only major exception to full prime contractor responsibility is the J-79 engines. They are provided by the Air Force under separate contract with General Electric. Substantially all other elements of the B-58 are procured or manufactured by the single prime contractor.

The matching of all the elements which make up the air weapon is a complex and laborious process. Each element affects some or all of the others. Among those elements which must be considered are powerplant, structural arrangements, aerodynamic shape, control system, bombing and navigation system, fire control system, electronic counter-measure systems, navigation system, communications system, crew duties, crew environment, equipment environment, and special problems dealing with safety, maintainability, and reliability, to name but a few.

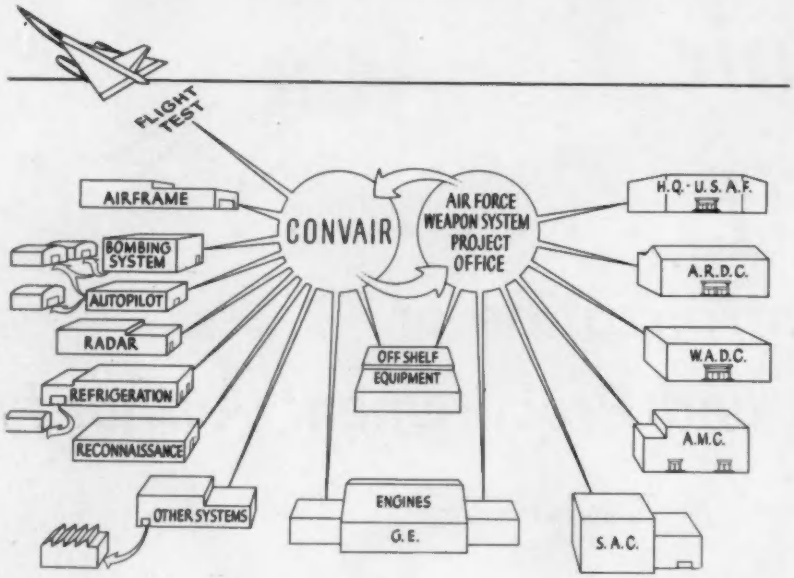
To investigate all of the effects of all the combinations of all of the variables is obviously a monumental task. But it has been found feasible to investigate and establish the effects of a large number of intelligently chosen variables in a reasonable time through application of computing machines such as IBM 701 and 704. It is necessary for the designer to apply imagination and critical judgment to the choice of elements to be combined and the variables to be investigated as well as in the interpretation of results which the machines may produce. Special analog computers have been developed for specific application to preliminary design problems wherein the designer can vary parameters at will and visually observe the results he is obtaining.

Integrated Electronics

The day when a voluminous airframe could easily accommodate an assortment of unmatched black boxes has gone. The contents of the black boxes are being called upon now to perform more and more functions, more and more accurately.

Today, they may constitute as much as half the value of the total air weapon. Their volume, environmental requirements, power requirements—and, more important, their capabilities—seriously influence the design of the airframe itself. The wasted volume and excess weight of the old-fashioned black boxes, their archaic cooling systems, their wide variety of power requirements, and their general disregard for the inputs and outputs of their neighbors—all these must go.

In the case of the B-58, integration of elements



SYSTEMS MANAGEMENT PARTNERSHIP between prime contractor and Air Force Weapon System Project Office ties all interested parties together so that problems can be solved promptly.

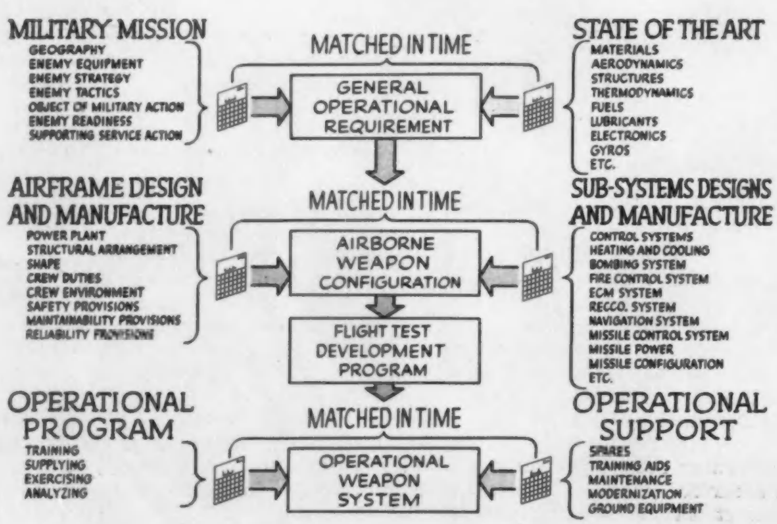
paid off both in performance of systems and in weight and space savings.

For example, a navigation and bombing system was devised which improved the accuracy of the best preceding system by a factor of 10 but which used only 63% of the volume and 81% of the weight.

Installed weight was only 64% of the best previous system. The relatively greater improvement in installed weight arises from more efficient marriage of this system to other systems in such matters as power supply, input and output signals, cooling requirements and wiring. The realization of this kind of improvement—some greater, some less—throughout all of the 16 subsystems contained in the B–58 constitutes a major advance in the state of the art of weapon system design. Some further idea of the degree of integration which must be achieved may be obtained from the fact that over 500 electrical inputs and outputs of the several subsystems had to be properly matched to achieve an integrated system for the B–58.

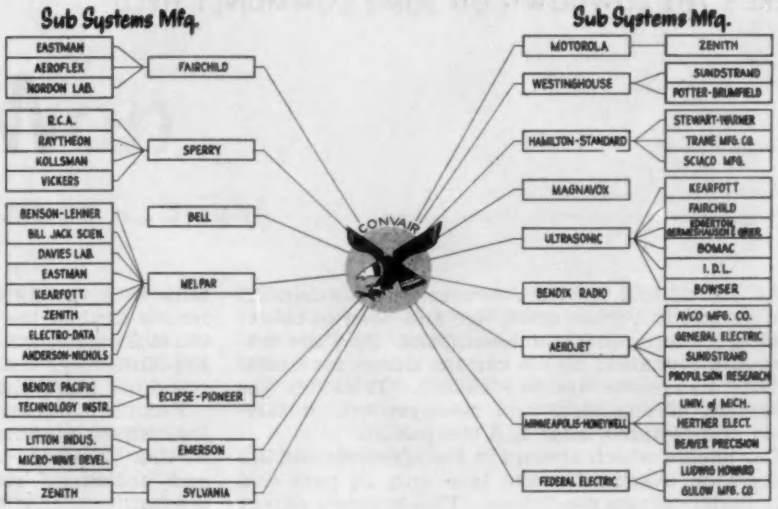
Airborne Computers

Even greater gain from proper combination and integration may be expected in the future with the widespread application of airborne digital computation quipment. This will make possible the centralization of many computing functions in one cen-



HUNDREDS OF FACTORS must be matched in time to achieve a satisfactory air weapon system.

ENGINEERING EFFORT OF SUBSYSTEM CONTRACTORS not counting the second and third tier, was more than twice that of the prime contractor, in the case of the B-58 supersonic bomber. Prime contractor established requirements for the subsystems to achieve an integrated, efficient total weapon system. Subsystem contractors were often called upon for decisive guidance.



tral computing unit. The absolute necessity for integrated design of all the subsystems is obvious in this case.

The change to the single prime contractor or weapon system management procurement concept as applied to the B-58 requires a realignment of thinking regarding the way in which competition operates and exerts its influence. In the case of the independent procurement of many different items of equipment by the government, competition exists directly among the subsystems vendors to satisfy the particular government procuring agency responsible for their item of equipment. The government acts as the go-between from the subsystems designer and manufacturer to the airframe contractor. The influence of the airframe contractor, whose name the total weapon system bears, on the subsystem contractors is usually weak, particularly in the design stage. This tends to inhibit the degree of integration of the subsystems with the airframe and with each other.

Competition Still Strong

In the case of weapon system management, direct competition among the various subsystem vendors exists to become a member of a team led by the single prime contractor. The product of the team, which is an integrated weapon system, is, in turn, in competition with other weapon systems for inclusion in the nation's defense inventory. It is possible that a single subsystem vendor may supply more than one single prime contractor; however, in each case, he is obligated by direct contract to meet the requirements for each specific weapon system. It is our belief that a weapon system developed under this concept will achieve a greater advance in the state of the art, or will be built sooner than one built by the old way of doing things, or both.

There are other ways to speed the transition from idea to hardware, of course. And with the technological race as tight as it is, we can't afford to overlook any of them.

Other Ways to Cut Lead Time

One way is to simplify the weapon system by reducing its military requirements. There is pay dirt here, but it is dangerous dirt in which to dig. A weapon which has too little performance, or subsystems which are too crude, may simply be outclassed by the enemy's weapons. For example, an all-weather bombing threat must not be countered by a fair-weather-only weapon. It must be met by an all-weather defensive system.

Another way to simplify the weapon system is simplification through logical combination of like or similar functions occurring in the various subsystems, and better matching and integration of the various subsystems with each other and with the airframe. There is pay dirt here, too, and it is most attractive. Properly done, it can save engineering man-hours, testing and manufacturing facilities, cost, and maintenance.

We believe that the best weapon systems come from matching the mission to be accomplished with hardware considered feasible at the chosen point in the future. The best hardware results from centralization of authority—for both design and procurement—within a single air Force Weapon System Project Office and in a single prime contractor. We submit the B-58 supersonic bomber as evidence in support of this argument.

(Paper, "Concept, Design, and Manufacture of Supersonic Aircraft," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

HERE'S THE LOWDOWN ON SOME COMMONLY HELD

Myths of

THE myths and fallacies surrounding automation are doing it a grave disservice and need to be exploded. The unqualified assumption that the impact of automation makes certain things inevitable is both dangerous and misleading. It clouds the judgment of engineers and management; it misleads and disturbs labor and the public.

The cliches which abound in the speeches and literature on automation are true only in part and only under certain conditions. This becomes patent from studying 13 highly automatic production systems in a variety of industries, then checking the results against the experiences of another 30 firms. Careful examination of these industries, instead of hypothesizing, makes the lessons of automation stand out more clearly.

From the process industries, particularly oil refining, where automatic operation has been carried further than in metalworking, we can interpret and anticipate some of the ultimate effects of mechanization in the automotive field.

Let us examine some of the more common myths.

Myth No. 1

Automatic and Fully Automatic Factories

A three-year search has failed to turn up a single "automatic" factory, much less a "fully automatic" one. In every case the factory turns out to be a remarkable advance in mechanization, but it has not resulted in manless production. It also turns out to be a tremendous hodgepodge of semantic confusion and exaggeration.

These plants called "automatic" or "automated" are only more automatic than something that went before. There are hundreds, even thousands of people working in them. Automation is simply a matter of degree of mechanical sophistication and of the addition of more functions to the mechanization sequence. The "fully automatic" factory is still a myth and appears to be a very limited industrial concept.

Myth No. 2

Automatic Manufacturing Requires Feedback Control

If we define feedback as the regulation of a machine by its own analysis of its output (closed loop control), we find either none or remarkably little of it in most automatic production machines. Only the oil refineries show a significant amount of feedback control.

Much automatic machinery does use elaborate and intricate electrical, hydraulic, or electronic control systems, but these are largely programming devices. They guide or limit the machinery to perform a sequence of prescribed operations and very rarely correct machine adjustment in terms of output.

Since the need for correction is not great, feedback has no economic value. This is not to deny the importance of feedback control in many of the continuous-flow operations. There is no doubt that it will spread and make possible superior manufacturing systems and products. Yet control, alone, does not create automaticity.

Myth No. 3

The Only Motive for Automation Is Cost Reduction through the Elimination of Labor

Many firms do justify automation through labor savings alone. This is very short-sighted. The experience of the 13 firms studied revealed an astonishing range of motives as well as unanticipated benefits and secondary objectives that were not quantified.

The advantages are far greater in number and often in value than the average firm realizes. Not one firm in a hundred thoroughly explores the favorable (and negative) aspects of automation proposals. They rarely quantify anything but labor savings, hence overlook some splendid and valuable contributions. Here are some examples:

A parts firm cut lead time from 19 days to 2–3 days; an oil refinery from 4 days to 5 hr; a feed mill from 2 man-hr to 5 man-min. What would this mean to the average firm in customer service, inventory reduction, and production planning?

One firm justifies its automation solely on reduction of scrap; another on providing better working conditions which attracted and held women workers in a tight labor market.

Several plants have increased equipment utilization from about 60 to 80% because of continuity growing out of mechanized work-feeding and removal. This is a clear gain of one-third in produc-

Automation

Based on paper by **James R. Bright,** Graduate School of Business Administration, Harvard University

tion capacity without corresponding investment or plant expansion.

A fertilizer plant adopted automation because it enabled immediate pushbutton mixing of any of 500 formulations. Such product flexibility is totally beyond the conventional plant.

Reduction in capital investment is completely contrary to traditional automotive industry thinking about automation, yet this was the major reason for automation in the most automatic plant studied—an oil refinery. Here is a possibility rarely entering management's or the engineers' calculations.

Low maintenance cost is also a surprising advantage.

It is a mistake to think of automation as yielding a limited, fixed set of advantages and disadvantages. These vary widely and depend widely upon a host of factors in the individual case. Management should explore the full range of implications and quantify them wherever possible. Labor savings alone is a very naive and inadequate approach.

Myth No. 4

Automation Must Cost More Than a Conventional System

This definitely is not always true. An oil refinery adopted automation because a conventional plant would have cost $1000 per bbl of daily throughput; the automated plant only $700 per bbl. The automation cost less not because the equipment was cheaper, but because there was less of it. This happens in many industries. When the shrinkage of equipment volume is great enough, building and facilities requirements shrink, too, such that great additional reductions may occur.

The automotive industry normally faces heavy development costs because each piece of automation is a unique piece of machine design. In the process industries, on the other hand, many advanced plants are unique assemblages of fairly standard components, which means that engineering costs are reduced enormously. To the extent this trend is occurring in the automotive industry, we can expect the differential between "conventional" and "automated" to shrink.

Many so-called higher costs of automation are actually the costs of inadequately planned and organized automation efforts. Carelessness, ignorance, and human frailty may be at fault, not automation.

The truth is, the cost of automation is not so much proportional to the amount of automaticity as it is to the degree of novelty and uniqueness in what is attempted.

Myth No. 5

Automation Inevitably Raises Maintenance Costs

Many automotive and electrical equipment producers will insist this is so, and it often is. Yet the two most highly automatic plants studied—an oil refinery and a feed mill—actually reduced maintenance costs and difficulties by automation.

Oil refineries expect the maintenance force to be 50–60% of the total work force. In the automated refinery it was 20.5%, due to a significant reduction in machinery to maintain per unit of output. In the automated feed mill the one maintenance man formerly employed has been discharged. There has been no failure in 18 months of operation.

Maintenance is not proportional to automaticity. Well-proved, standard equipment can be highly automatic and quite trouble-free. It is the novelty that results in trial and error, hence in costly debugging and frequent failure until perfected. There are factors which tend to increase maintenance cost and others which tend to decrease it. Management should try to appraise the mix of these factors in their own case before assuming dire maintenance troubles to be inevitable with automation.

Maintenance figures and experiences as reported are totally misleading. The thing called maintenance is usually a blend of seven items, namely:

- Installation.
- Debugging.
- Routine servicing (lubrication, cleaning, adjustment).
- Downtime for tool replacement and the like.
- Housekeeping.
- Maintenance for tooling fixtures (as distinct from the production machine).
- Breakdowns.

No plant has been found where these factors are

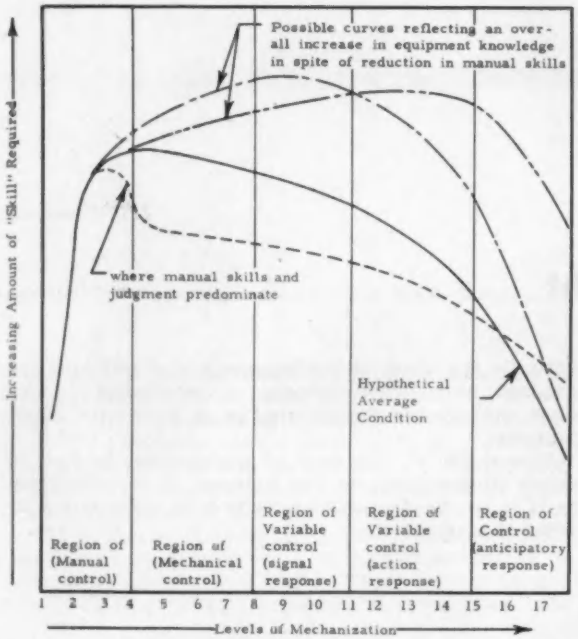


Fig. 1—Suggesting how skill requirements of operators may vary with levels of mechanization.

isolated. They are lumped together and charged to maintenance. Furthermore, we usually hear of maintenance as of the worst moment and not after the plant has learned to live with the system.

Myth No. 6

Automation Inevitably Means Upgrading of Labor Skill Requirements and Severe Retraining Problems

It is one of the phobias in some circles that the average worker is unemployable in the highly automated plant. The evidence in the 13 plants studied is mostly to the contrary. To the extent that employment opportunities are available (a) operators' jobs often are easier and more quickly mastered in the automated plant and (b) the impact on the quantity and quality of maintenance skills required may be much less than expected.

The impact of higher levels of mechanization leads to what is termed roughly the "hump in skill requirements," as seen in Fig. 1. "Skill" is used broadly to mean the combination of the necessary experience, dexterity, and technical knowledge. The highest forms of skill frequently occur on level 2, where the hand tool operator expresses the ultimate in craftsmanship.

Automation was found, generally, to reduce the demand for skill and knowledge on the part of the operator after reaching mechanization level 5 because the machine takes over more and more of these elements of the task. Thus, automation does not tend to make people unemployable because they lack skill and specialized education. On the contrary, many (perhaps most) operator jobs can be mastered more quickly with less job experience, special skill, and education as mechanization increases past level 4 and provides increasing degrees of automaticity.

The study of the 13 firms brought out four extremely valuable points:

1. Automation did not force management into drastic measures because of increases in operator skill requirements.
2. There was and is a scarcity of maintenance electricians trained in electronic work, but only something like a tenth, or perhaps a fourth, of all electricians currently need this training.
3. Hydraulic and pneumatic repairmen of adequate ability are not common, but relatively few firms ran into difficulty here.
4. Firms designing and building their own machinery see a distinct shortage of machine designers, engineers, and mechanics with machine-building skills.

This study suggests that if management elects to go automatic it can run the new plant with its existing work force. It also shows that there will be no difficult retraining problem, with due allowance for minor exceptions and some, but not all, of the maintenance job. There is actually a good possibility of lowering skill requirements and shortening the training period on many operating jobs.

Myth No. 7

Automation Has Nothing to Offer Labor But Unemployment

Many (probably most) automation programs aim at reducing direct labor content per unit of output. However, most such programs are also sparked by the need for increased capacity. The net effect can be anything from unemployment to far greater employment opportunity.

Ford started automating in 1947, yet today employs 40% more people. This is not because of automation, but in spite of it.

Although the net effect on employment opportunities is uncertain, there is no doubt at all that automation offers the worker distinct job advantages. For operating labor, automation means:

1. Easier work, physically and mentally.
2. More interesting work through variety of job activity.
3. A more satisfying job through a sense of responsibility for a larger portion of the end result.
4. Pleasanter job surroundings.
5. Higher pay through increased productivity.
6. The satisfaction and prestige of working in an outstanding plant.
7. Greater job security against both the efforts of the firm's competition and the effects of old age on the individual's strength, dexterity, and endurance.
8. Greater continuity of employment, because the automated line usually cannot operate in fractions, or unless fully manned.
9. A safer job.
10. The pride of running a fine machine.
11. Opportunity to learn more of the total production process and machinery.

12. Experience with advanced equipment that may be even more valuable as time goes on.

Of course, all these things do not apply in every situation. The point simply is that the worker has much to gain from automation. Why not tell him so?

Myth No. 8

Automatic Machinery Alone Is Responsible for Sensational Advances in Automatic Manufacturing and Productivity Increases

There are at least five major factors involved in technological improvements:

1. Spatial arrangement of machinery to provide a more efficient sequence of activity.
2. Changes in materials to facilitate automatic production. Materials may block or advance the automatic aspect of production techniques.
3. Changes in process to facilitate mechanization.
4. Changes in product design.
5. Automatic machinery. This is the most spectacular, but often it is not a radical machine concept but rather the mechanization of an act that was made simple (or eliminated) by changes in arrangement, process, material, or design, as mentioned above.

To look to automatic machinery as the sole hero or villain of automatic production, productivity increases and/or labor displacement is industrial naivete of the first order.

There are other myths and fallacies of automation that should be exploded for the good of our economy and society, and to help the industrialists develop the implications of their programs in an atmosphere of understanding. But it is a grave mistake to assume or insist that there is no truth at all in them. The negative aspects of automatic production do sometimes happen. They happen because of the mix of factors present in the peculiar situation, not because there are immutable laws of mechanization and inevitable drawbacks to every automation program. The industrialist needs to analyze those factors in order to make surer judgments as to the end results in his particular case.

(Paper, "Myths and Fallacies of Automation," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Lycoming T53 Gas Turbine . . .

. . . designed for low-cost production, versatility, reliability, and ease of maintenance to compete with reciprocating engines.

Based on paper by **Dr. Anselm Franz,** Lycoming Division, AVCO Mfg. Corp.

THE T53 offers a good example of ruggedness and ease of production in the blades of its 5-stage axial compressor, which are made of 403-type stainless steel. The aerodynamic and mechanical design allowed the use of a low hardness level to safeguard against impact failures and to avoid stress corrosion cracking.

How well this design has stood up against breakage is exampled in Fig. 1. A compressor rotor swallowed a chunk of magnesium approximately $2 \times 3 \times 0.3$ in., but, although the axial compressor blades are twisted and bent, not a single one broke.

One reason for selecting a centrifugal compressor stage was to avoid the small and delicate blades of the latter stages of an axial compressor. The centrifugal stage has proved to be very rugged, none having been lost in 2000 hr of operation. Even in the example just cited, the impeller, which is fabricated of 422-type stainless steel, suffered no significant damage.

A constant cross-section blading for each wheel and stator is provided in the aerodynamic design of the axial compressor. This permits use of twisted sections of precision-rolled airfoil strip for compressor stators and has reduced the cost of stator vanes from $10 to 35¢ a piece. An axial wheel with similarly fabricated rotor blades has been operated for 300 hr. This method of manufacture is expected to reduce the price of a rotor blade from $14.50 to $1.50. (Paper "Some Experiences in the Development and Application of Lycoming's T53 Gas Turbine Engine," on which this abridgment is based, is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

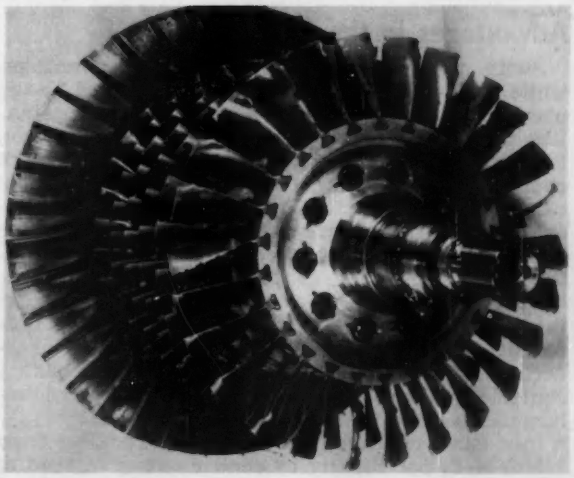


Fig. 1—Axial compressor blades are twisted and bent, but none broken, following ingestion of chunk of magnesium approximately $2 \times 3 \times 0.3$ in. in size by compressor rotor.

Shell Molding . . .

. . . makes better cast crankshafts with lower foundry

Based on paper by **H. N. Bogart,** Ford Motor Co.

BY shell molding its cast crankshaft, Ford is realizing varied advantages in its foundry processes, in its machining operations, and in the performance of the resulting crankshaft itself. Continued search for manufacturing economies sparked Ford's development of the first cast automotive crankshaft back in 1933, as well the recent step to shell molding.

Reduction in machining costs was the primary reason for going from forging to casting, with increased design flexibility supplying the secondary motivation. The outstanding advantages of shell molding are:

For the foundry:

High degree of automation permitted.

For machining:

Less machining; reduction in tool costs.

For engineering:

Exceptional wear resistance of product.

Advantages in the Foundry

Shell molding has gained process advantages while retaining all of the advantages secured by the previous casting method. Adaptation of automation begins in the melting area where nodular iron is produced continuously from advanced design cupolas and continues throughout the molding, cleaning, and inspection operations (Fig. 1). Moreover, the operations are so divided that an effective combination of mechanical action and manual labor is possible (Fig. 2).

The maintenance of closer tolerances from casting to casting is another advantage. Improved uniformity results not only in dimensionally near-perfect crankshafts, but also permits use of quality control procedures for inspection, gaging, and metallurgical examination.

Raw sand requirements have been reduced from 125 to 20 lb per casting by shell molding instead of normal casting. This conserves good foundry sand and simplifies the problem of refuse sand disposal.

Foundry engineering needed to meet quality standards during model change-over has been substantially eliminated. Similarly, there is less pattern maintenance.

Foundry conditions have been vastly improved. With less hard manual labor, less sand required, and greater cleanliness of the castings, operations have become cleaner, less fatiguing, quieter, safer, and healthier.

Advantages in Machining

The superiority of the shell molded cast crankshaft, as it is received for machining, compared with a crankshaft made by any other process, has made it possible to reduce manufacturing costs still further. Increased casting precision has resulted in a reduction in the finish stock from 9.5 lb in the previous casting practice to 5.5 lb. Going from a forged to a shell molded crankshaft has meant a reduction of 70% in the weight of chips produced. This spectacular reduction in total machining has had an obvious influence on machine cycle time and minute cost. Moreover, the increased precision with the absence of warpage allows fast traverse in many machining operations until actual contact is made between the tool and the workpiece.

The closer tolerances in the casting procedure also improve the balancing operation. By very close control of the balance weight location, preliminary balance has been eliminated and final balance has been limited typically to drilling a 7/8-in. diameter hole less than 1 in. deep into the two end counterweights. Similarly, the centering operation itself has been so simplified by the careful control of mass location that mass centering machines have been eliminated. Present practice uses geometric centering 100%.

Illustrative of the close tolerances to which these castings are held is the fact that in a recent model year, one million crankshafts with an allowable 0.0285-in. clearance between the crank cheek outside diameter and the camshaft distributor gear were assembled into engines without machining at

and machining costs.

Fig. 1—Shell molding permits high degree of automation in foundry. Shell molds are being poured here.

this location. There was not a single instance of interference.

Tool costs have been materially influenced by shell molding. The precise location of all portions of the casting has reduced tool and machine tool damage due to inadequate clearance during machining. Moreover, the absence of small sand particles in the casting skin has been a potent factor in cutting tool costs.

Engineering Gains from Shell Molding

The shell molded crankshaft has the best wear resistance of any material ever used in our automotive crankshaft manufacture (Fig. 3). This is attributable to the self-lubricating property of the free graphite on the bearing surface and it is noteworthy that this advantage is gained in a material whose physical properties compare with those of steel in many ways.

A second engineering characteristic is the exceptional endurance of the crankshaft, which is attributable to the improved damping characteristics of the graphite-rich material, the absence of casting defects such as shrinkages and blows, and good design coupled with good manufacturing procedure.

Additional design leeway is still another advantage. It allows a more efficient distribution of weight and contributes to engine compactness by varying the casting contour to prevent potential interferences. And, finally, there is the advantage of an improved consistent balance attainable at a minimum cost. This eliminates drilling balance holes or grinding for balance in critical areas without adequate care to prevent weakening the entire component, leading, and other salvage expedients used to obtain physical balance.

(Paper, "Shell Molded Cast Crankshafts," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

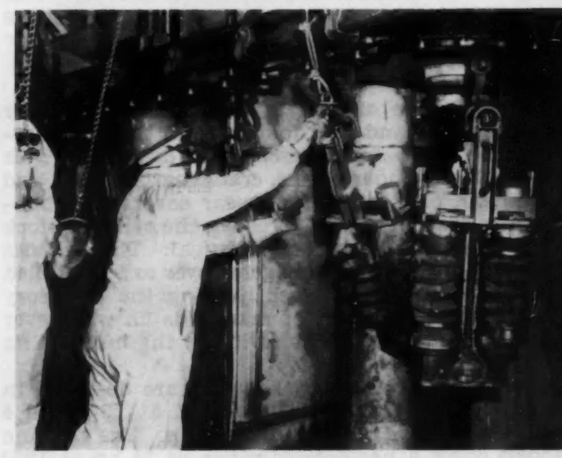


Fig. 2—Shell molded cast crankshafts at shake-out station. Foundry operations are divided in a manner to permit effective combination of mechanical action and manual labor.

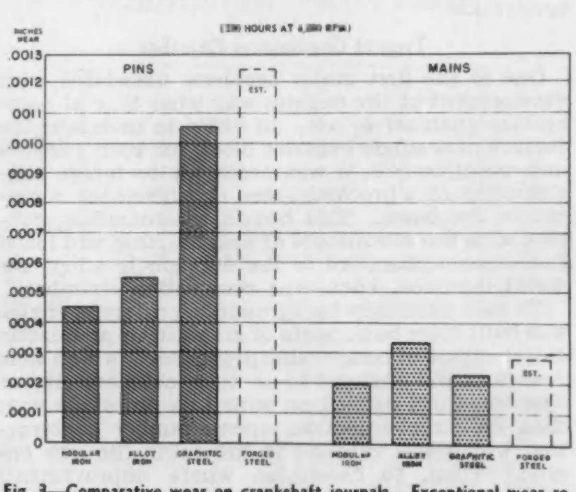


Fig. 3—Comparative wear on crankshaft journals. Exceptional wear resistance of shell molded cast crankshaft is attributed to self-lubricating property of free graphite on bearing surface of nodular iron.

Hercules Interchangeable Engine

THE new Hercules series of 18 interchangeable diesel and gasoline engines of various sizes has 87% of the total number of parts common to all the engines.

Interchangeability

The exchange of fuel injection pump, cylinder heads, pistons, and manifolding is all that is necessary to convert from gasoline to diesel and vice versa. The cylinder blocks, crankshafts, valves and valve gear, connecting rods, gear covers, and bellhousings are identical. Moreover, the cylinder block is designed with both ends identical. This enables the bellhousing and timing gear cover to be installed on either end of the block, placing the accessory drive and arrangement of manifolds on whichever side of the engine is best suited to the installation requirements.

Both gasoline and diesel models are designed in 3-, 4-, and 6-cyl sizes, with bores of 3½, 3¾ and 4 in. The stroke of all engines is 4½ in. The gasoline models cover a horsepower range of 25 hp at 1200 rpm to 130 hp at 3000 rpm; the diesels range from 25 hp at 1200 rpm to 100 hp at 2000 rpm, although higher speeds may be permitted depending on the application.

Type of Combustion Chamber

One of the first major problems associated with development of the engines was what type of combustion chamber to use. In order to maintain the feature of a single cylinder block for both gasoline and diesel models, it was necessary to forego consideration of a precombustion or turbulence chamber in the block. This design consideration, coupled with the advantages of easy starting and lower fuel consumption, led to the decision to adopt the direct-injection, open-type combustion chamber.

To gain necessary background, a prototype engine was built from basic parts of an existing production diesel engine of comparable proportions, which were reworked and changed to an open-chamber engine. The test work carried on with this prototype gave data on direct-injection, open-chamber construction which was valuable in designing the new engine. Then, to determine where improvements could be made and what the problems were, investigations were programmed involving tests on the air induction system, air turbulence within the combustion chamber, rate and timing of fuel injection, fuel spray characteristics, and engine cooling.

The development of the combustion chamber in the piston head can be divided into three phases:

1. Since the injection nozzle is located in the cylinder head at an angle to the centerline in the cylinder, the axis of the fuel spray (from two of the nozzle holes) forms a different angle to the nozzle centerline than the axis of the spray from the other two holes. This difference in angle was found to result in somewhat different spray characteristics from the two pairs of nozzle holes and the best performance was obtained when the center of the combustion chamber was located at a different off-center position than the center of the nozzle tip. Fig. 1 shows the difference in performance obtained with two of the piston designs tested having different off-center locations of the combustion chamber. The nozzle tip is located 13/32 in. from the centerline of the cylinder.

2. Configuration of the combustion cavity has pronounced influence on engine performance. Piston design X-22 in Fig. 2 gave better turbulence. More complete combustion was obtained with the "squish" effect linked to this particular shape.

3. Engine output is not too sensitive to change in compression ratios ranging from 13.6/1 to 16.5/1. Engine starting is affected as the ratio is lowered and cold-starting tests had to be conducted to determine the ratio permitting starting at a predetermined temperature.

Design for Production

Each part of this series of engines was studied carefully with the thought of minimizing production equipment cost and labor cost, yet providing maximum flexibility to suit future product developments. In the machining of the block, for example, in actual design the line is tooled for the 6-cyl block. Changeover to a 4- or 3-cyl block (of any model) is accomplished by quick removal of unrequired tools and minor adjustments to part locating mechanisms. The block design lending itself to this arrangement is shown in Fig. 3. The 4-cyl engine is a section of the six, and the 3-cyl engine also dupli-

• Comes in 18 varieties
• Gasoline or diesel powered
• 87% of all parts in common

Based on paper by **John F. Male,** Hercules Motor Corp.

cates the spacing of the six. Not only are cylinder bores on the same centerline, but other holes for water passages and head bolts are of the same spacing.

The cylinder-head tooling posed a more difficult problem since there are two cylinder heads for each of the three cylinder blocks (one gasoline, one diesel) or a total of six different heads. Fig. 4 shows the 4-cyl gasoline head on the right and diesel head on the left. It was still found possible to design machines which would process either head, regardless of model, yet incorporate the readily accessible quick-change features typifying the block line.

The standardized design of the entire series of engines simplified assembly to such an extent that it is feasible to schedule any combination of bore size, number of cylinders, gasoline or diesel, right-

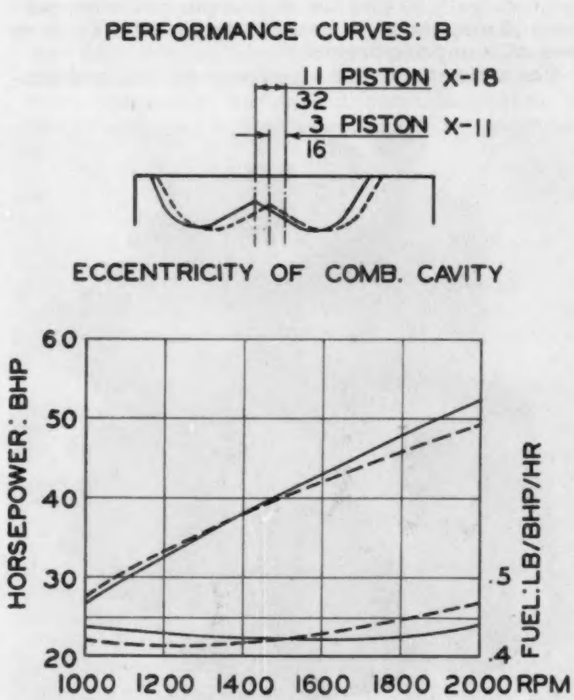


Fig. 1—Best performance was achieved when center of combustion chamber was located at a different off-center position than center of nozzle tip.

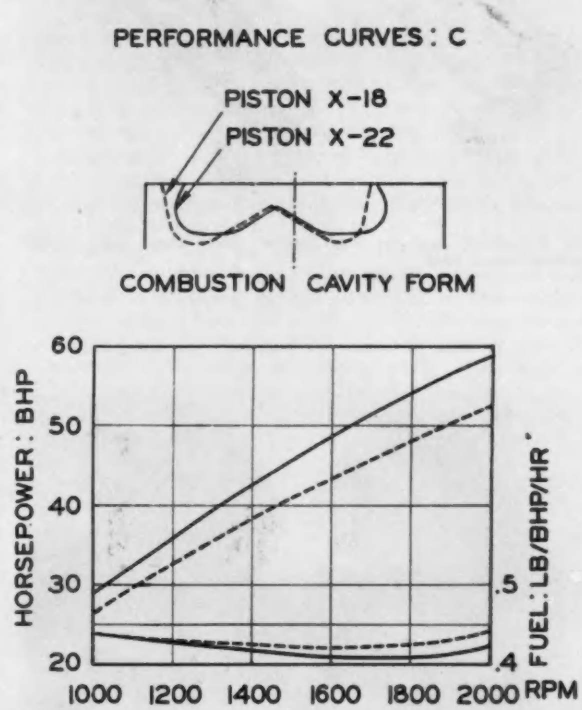


Fig. 2—Configuration of combustion cavity has pronounced influence on engine performance. Here two piston designs are compared.

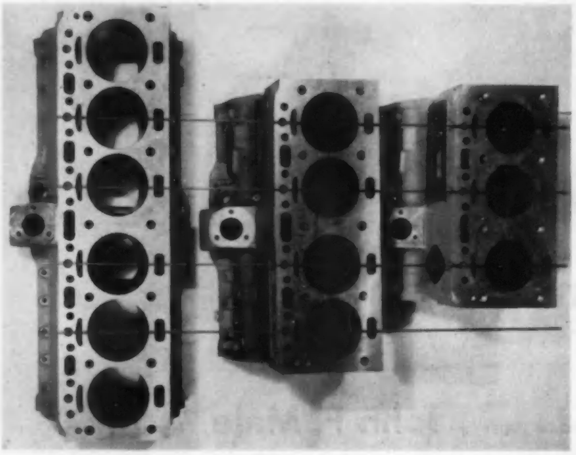


Fig. 3—Cylinder-block design lends itself to easy machining regardless of number of cylinders.

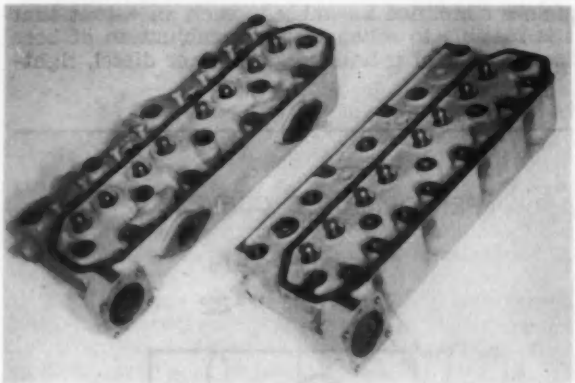


Fig. 4—Cylinder head for 4-cyl engine, (left) diesel head, (right) gasoline-engine head.

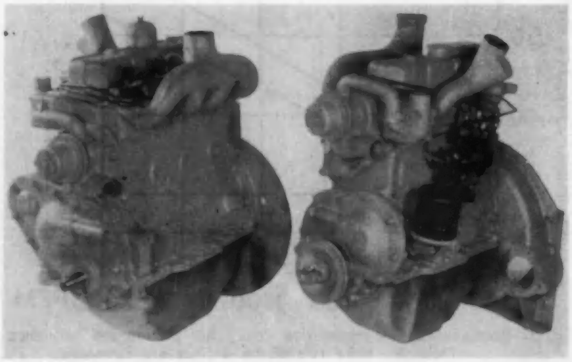


Fig. 5—Basic engine has 2-gear front end. Timing gear housings are available for engines assembled with camshaft on either right- or left-hand side of cylinder block.

or left-hand rotation, and so on, for assembly on the mechanized assembly conveyor.

Design for Varied Application

A main requirement in the design of these engines was to make them adaptable to a wide variety of applications. This required a construction to make the engines offer all the special engineering features required for these installations and to be able to produce them economically. Here are some of the ways this was accomplished:

Major component parts—cylinder block, head, crankshaft, and camshaft—can be used regardless of special installation.

Timing gears are placed in a gear housing machined independently of the cylinder block and bolted to the front end of the block. Different arrangements of gears for accessory drive can be provided by producing different gear housings without a change in the block. These in turn can be used interchangeably with gasoline or diesel engines of any cylinders.

The flywheel housing is bolted to the rear of the block and can be varied readily to suit the installation. All flywheels and housings can be used interchangeably on the different models.

Front and rear engine mounts are provided on timing gear housing and flywheel housing respectively and can be changed as required for given applications by simple and economical combinations to the pattern equipment for these parts. Single-point, pad, arm, or trunnion type mountings can be supplied.

The bolting and sealing of the oil pan was laid out symmetrically so that the oil pan can be turned end-for-end and the same pan can be used for front or rear oil sump requirements.

The basic engine has a 2-gear front end, and tim-

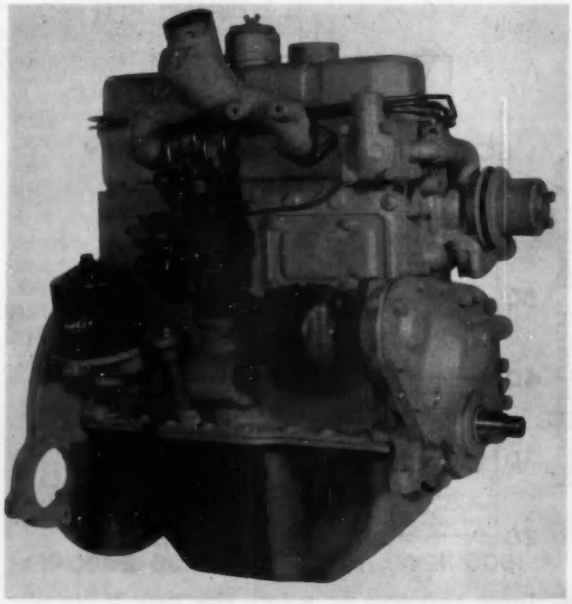


Fig. 6—In one assembly, hydraulic pump is driven by extra gear which engages into camshaft gear, as shown. For larger pumps, sprocket is placed on crankshaft in front of timing gear and pump is driven by roller chain.

ing gear housings are available for engines assembled with camshaft either on the right- or left-hand side of the cylinder block. This is shown in Fig. 5.

Two different types of timing gear housings for hydraulic pump drive are available. In one assembly, the hydraulic pump is driven by an extra gear which engages the camshaft gear (Fig. 6). For larger pumps which might require as much as 60% of the power of the engine, a sprocket is placed on the crankshaft in front of the timing gear, and the pump is driven by a roller chain. In either case, the hydraulic pump is mounted on the gear cover.

(Paper "Design and Development of New Hercules Interchangeable Diesel Engine" on which this abridgment is based, is available in full in multilith form from SAE Special Publications; 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Turboprops . . .

. . . under service test prove satisfactory in operation and maintenance. Will power newest military transports.

Based on paper by **Maj. Gen. Brooke E. Allen,** Commander, Continental Division, MATS

THE military air transport service has completed tests of the Allison YT-56-A3 engine in two Convair YC-131C's and is putting the Pratt and Whitney T-34 through similar tests in YC-97J and YC-121F aircraft.

In around-the-clock operation, the YC-131C's completed 3,332 hours of flight with results which may be summarized as follows:

1. Humidity effect on available shaft horsepower is negligible.
2. Excellent climb characteristics make operation at altitudes between 25,000 and 30,000 ft practical on comparatively short flights.
3. Operation over typical domestic route structure indicates an excellent potential, with notable decreases in enroute time. Simple ground operation with practically no ground run-ups, makes the equipment more practical on tightly scheduled routes.
4. With one propeller feathered, an altitude of 21,000 ft, with gross weight of 43,400 lb, could be maintained. This is well above minimum enroute altitude for most airways. Failure of the feather pump to actuate will not affect safety because directional control and air speed can be maintained with normal hydraulic action maintaining a pitch angle of 86 deg. The recommended altitude for air starts is 20,000 ft or below.
5. Normal cruise operation between 25,000 and 30,000 ft altitude is practical except for cabin pressurization limitations (4.16 to 1). Aircraft and engine performance above 30,000 ft is very satisfactory.
6. Over 6000 hr were accumulated on 7 Aeroproducts turbine propellers with gratifying results. Propellers of the 198A series were installed near the end of the test and were considered superior to the 198. The 198A had two added safety devices. An NTC (negative torque control) installed within the propeller completed the mechanism necessary to decrease windmilling drag during engine failure, while a blade and spinner de-icing system increased all-weather capabilities.

The negative torque-sensing units were thoroughly tested on engine run-up. Circuitry which provided a system of checking this unit was also ground checked. High speed taxi tests were conducted to determine directional control and to ascertain the possibility of ground starting by windmilling the propeller. The negative torque unit was tested in flight at the 5000 and 10,000 ft levels. Fuel flow was stopped by positioning the condition lever at the mechanical fuel-off position. This produces a negative torque signal, driving the propeller blade angle toward the feathered or increased pitch position.

A rate of climb of 300 ft/min could be established at 10,000 ft at 125 knots IAS in a clean configuration with the operating engine at maximum power. At 5000 ft, with take-off flaps, a rate of climb of 500 to 600 ft/min was established at 125 knots IAS. Loss of an engine at take-off was simulated by slowing the aircraft to 110 knots IAS at 5000 ft, gear up, flaps at the take-off position (17 deg). The power levers were advanced rapidly to the take-off position and one condition lever moved to the mechanical full-off position simultaneously.

Inasmuch as the negative torque sensing unit is a mechanical, positive action type, it is deemed unnecessary to use the system before every take-off. NTC checks should be made at the time of propeller installation and at periodic intervals thereafter. The blade angle change toward the increased pitch position is dictated by the strength of the negative torque signal, and the blade, although capable of a change rate of 17 deg/sec, actually moves at a decreasing rate until the pitch angle and rpm are commensurate with a negative torque signal of 250 to 275 hp. The tests at 10,000 and 5000 ft indicated adequate directional control with the present system.

Although tests of the Pratt and Whitney T-34 have not been completed, the engine TBO has progressed well in advance of the potential and an 800 hr TBO should be established at the completion of the service test program. Validation of the T-34, to be used on the production C-133A, has been advanced by making the engineering improvements which difficulties encountered to date indicate to be necessary.

(This abridgment is based on paper "Operating Experience With Turboprop Engines." For complete paper in multilith form write SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Reasons Behind Design Features of Postwar

Daimler-Benz

MANY interesting problems and decisions were involved in arriving at the engine design for Daimler-Benz race cars following World War II.

Daimler-Benz chose to power its postwar race cars with a 2.5-liter naturally aspirated engine rather than with a 750-cc supercharged engine (the other choice permitted by postwar international racing regulations) for several reasons. Among them:

- The unaspirated 2.5-liter engine showed an advantage when relative torque curves were compared.
- An output of about 115 bhp/liter (about 290 hp at 8000 rpm) could be expected of the 2.5-liter engine. To get the same result from the 750-cc blown engine an exceptionally high boost pressure (in the order of 3.3 atmospheres or 48.35 psi) would be required.
- Estimated fuel consumption would be less.
- Racing experience gained on the unblown engine could more easily be applied to the firm's production engines.

Valve Arrangement

To get maximum cross-section areas (important to the highest possible degree of cylinder filling), a new valve arrangement was devised (Fig. 1). With this it became possible to arrive at generous valve openings which never could have been obtained with a normal gear arrangement.

The left-hand portion of Fig. 1 shows the usual layout with cam, valve, valve-spring, and cotter. The opening of the valve by the cam compresses the valve-spring. On closing—when the cam has moved on—the spring closes the valve against the cam. The strength of the spring, therefore, is the deciding factor for the closing operation.

With desmodromic valve gear there are two cams per valve. One is directly above the valve and is responsible for the valve opening. The other closes the valve via the rocker arm. The desmodromic valve gear enables acceleration values to be obtained that are higher than we have ever realized with conventional gear. Fig. 2 gives direct comparison values for a racing engine with spring-operated valves and the new desmodromic actuation. Higher rates of acceleration and deceleration are possible with the new system. So, the angle of opening can be kept relatively small—and comes close to an ideal situation.

It has been found that the 8-cyl in-line engine offers many advantages if the drive is taken from the middle of the crankshaft. Then the crankshaft and drive layout (Fig. 3) provides, in fact, a 4-cyl engine on each side of the power take-off. This helps reduce torsional vibration, as shown in the lower half of Fig. 3. The central drive take-off permits dispensing with the flywheel. The two small vibration dampers at the end of the crankshaft are sufficient. Also, the propeller shaft is moved so far to the car's side that it can lie alongside the driver's seat. Thus, the vehicle acquires a lower center of gravity.

Fuel Injection Used

Experimental results showed that, with fuel injection, 10% more bhp could be developed from the 300 SL engine than with a carburetor. That was a main reason for applying fuel injection. Maximum bhp with the engine carbureted was 200; with fuel injection 220.

Other fuel-injection advantages, tests showed, included:

- Lower fuel consumption.
- Elimination of "flat spots." (The 300 SL sports car can be driven without difficulty at 15–20 mph in top gear . . . and, without a gear change, accelerated to its maximum 160 mph.)

Brakes

Positioning of front brake drums and shafts to the front wheels made it possible to keep unsprung masses to a minimum. The large brake drums permitted on the front are desirable to meet the particularly high brake forces on the front wheels. The joints of the shafts are contained in sleeves. Wishbone arms support the wheels. Torsion bars are used as springs.

On the front brake drums the inner cast ring is bonded directly to a Silumin light alloy drum by the Al-Fin process. The outer drum carries radial fins, which simultaneously cope with heat dissipation and air disposal. . . . For better ducting, a light metal alloy cover is fitted over the drum. This construction prevents brake fading, because the heat generated under repeated sharp brake application is quickly dissipated. So, wear and tear on brake lining are small.

Axles

The casing of the normal swing axle is fixed to the chassis by rubber bushings. The two half-

Based on paper by **H. Scherenberg,** Daimler-Benz A.G. Germany

Race Cars

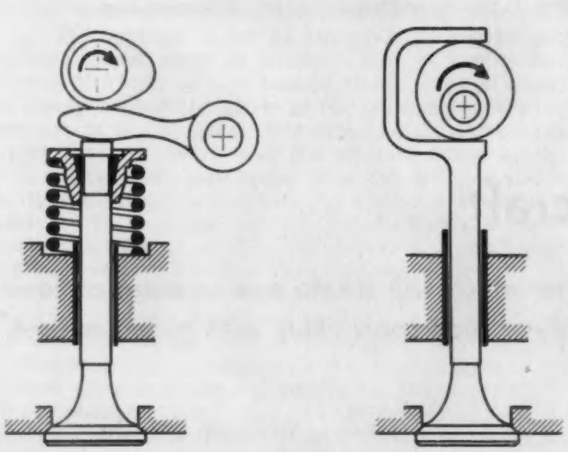


Fig. 1—Valve actuation with (left) normal cam and (right) desmodromic gear.

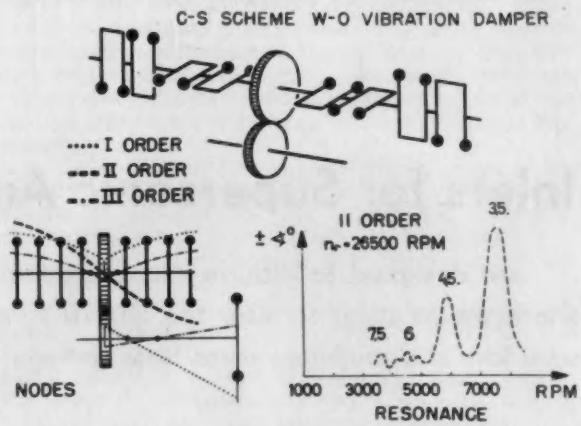


Fig. 3—Crankshaft scheme of 2.5-liter racing car and vibration chart.

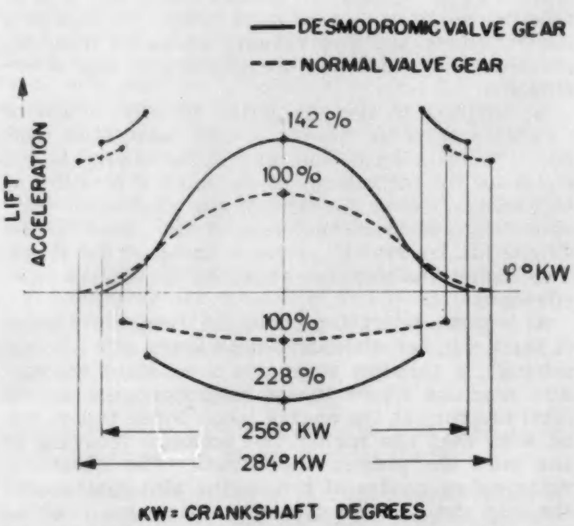


Fig. 2—Comparison of lift and acceleration curves.

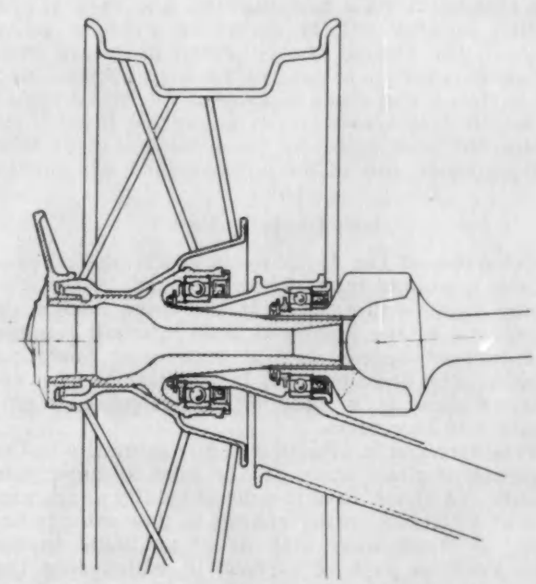


Fig. 4—Rear-axle and wheel hub of 2.5-liter racing car.

shafts are joined at the casing. The outer axle shaft joints are mounted coaxially with the inner shaft.

On the single joint system there is but one common, low-mounted pivot, which is attached to the frame. . . . And only one joint connects the two half-shafts. So, the casing swings with the right-hand axle shaft. This combination makes for good cornering.

We strive to build a car which will oversteer and understeer as little as possible. But, in the borderline cases, we think a slight oversteering tendency is the better.

The rear-axle layout of the 2.5-liter race car has two half-shafts, joined by one pivot. These are mounted low under the center of the rear-axle housing. There are also inboard brake drums.

The section through the hub in Fig. 4 makes apparent the care expended to minimize weight as far as possible. Stress calculations were made for each of the various sectional areas.

Particular stresses appeared at the inner hub. The lateral forces which bear on the tire—together with the wheel loading—are increased by shocks and applied power. So, they provide combined and particularly unpleasant stresses at the point where the inner part leads to the bell-shaped portion. The shape (shown in Fig. 4) keeps the maximum stress at the most critical cross-section down to 21 tons per sq in.

(Paper, "Mercedes-Benz Racing Cars—Design and Experience," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers.)

Inlets for Supersonic Aircraft . . .

. . . are designed to include variable geometry which will create one or more oblique shock waves so as to slow the airflow to a lower supersonic value with minimum pressure loss and minimum mass flow spillage.

Based on paper by **William Stubbs,** Lear, Inc.

THE throat area is also varied so that the normal shock wave is swallowed by the inlet, thus insuring maximum mass flow capture, and so that the airflow velocity will be decreased prior to going through the normal shock. Bleed doors are then manipulated so as to control the back pressure and cause the normal shock to occur at the throat (point of lowest flow velocity). It is general practice to design the inlet such that the pressure loss at each oblique shock and at the normal shock are equal.

Inlet Design Problem

Extension of the flight speed spectrum has presented a serious inlet design problem to the airframe manufacturer in that the same inlet must supply air to the engine at both subsonic landing and take-off speeds, and at supersonic operating speeds. The basic problem is a matter of inlet efficiency—that is, a duct with high subsonic efficiency and vice versa.

This decrease in efficiency is due primarily to the presence of shock waves in the inlet at supersonic speeds. (A shock wave is a discontinuity of the airflow at which an abrupt change in flow velocity occurs. A shock wave may be at an angle to the streamline or path of airflow, in which case the shock is termed an "oblique shock." Or the shock may be perpendicular to the streamline, in which case it is called a "normal shock.")

The direction as well as the velocity of airflow is changed at an oblique shock, the change in direction being dependent upon the velocity of the air ahead of the shock. The velocity of the flow decreases going through an oblique shock but usually does not decrease to a subsonic value. In case of a normal shock, the flow velocity decreases from supersonic to subsonic and the direction of flow is unchanged.

In addition to the change in velocity, a loss of useable energy in the air is also associated with shock wave and this loss of useable energy is the cause for the inefficiency of the inlet. A measure of this energy loss is the ratio of the stagnation (reservoir) pressures downstream of the shock to the stagnation (reservoir) pressure ahead of the shock. The higher the pressure ratio the higher the inlet efficiency.

At a given operating condition (constant values of Mach number, altitude, temperature, and throttle setting), a turbojet engine is a constant-volume-flow machine whose thrust is proportional to the total pressure at the engine face. From this it can be seen that the higher the pressure recovery of the inlet the greater the thrust. The constant-volume-flow nature of the engine also complicates the inlet design since major consideration must be given to supplying the correct volume of air for the engines at a given flight condition, but if excess air is captured, a back pressure is created in the inlet.

This back pressure can disturb the flow pattern and so reduce pressure recovery.

Compromise of the inlet design yielding acceptable engine performance throughout the flight regime has not been possible so provision has been made in most high performance aircraft to vary the geometry of the inlet so as to get optimum engine performance at each flight condition. (The control of this geometry variation creates a vast potential equipment market and so is of urgent importance to Lear.)

As an example, Fig. 1 represents the general variable geometry inlet design for a pod mounted engine. In this scheme a conically shaped centerbody (spike) is translated fore and aft, controlling the position of the oblique shock wave generated by the conical section of the spike and varying the throat area. These two functions of the spike are:

1. The conical shape of the spike generates an oblique shock wave as shown. The airflow is deflected through an angle equal to the conical angle of the spike, but the angle of the oblique shock with respect to the original flow direction is dependent upon Mach number and the conical spike angle. The energy loss associated with the oblique shock is dependent upon flow velocity ahead of the shock and the spike angle. If the oblique shock is positioned just ahead of the inlet lip, there is minimum spillage of flow and hence minimum drag.

2. The shape of the spike and of the cowl surface forms a diffuser with area converging to a section of minimum area which is termed the diffuser throat and then diverging to the engine face. The throat area decreases as the spike moves forward. Supersonic flow acts contrary to subsonic flow in that the speed of flow decreases with decrease in area, whereas subsonic flow follows the venturi relation in which velocity increases as area decreases. The converging area portion decreases the supersonic flow velocity prior to going through a normal shock and the diverging area decreases the subsonic flow velocity downstream of the shock.

After the spike has been positioned so as to determine the throat area, the position of the normal shock wave in the inlet is determined by the ratio of the engine back pressure to the free stream pressure. The addition of bleed doors adjacent to the engine to bleed off excess air and thus reduce back pressure allows control of the position of the normal shock wave at point of minimum flow velocity to obtain best pressure recovery.

Various current airplanes incorporate either variable spike or bleed doors or both in their inlet design.

The pressure loss across a normal shock wave and flow instability are negligible at speeds below approximately Mach 1.4, so inlet control need not begin until this speed has been reached.

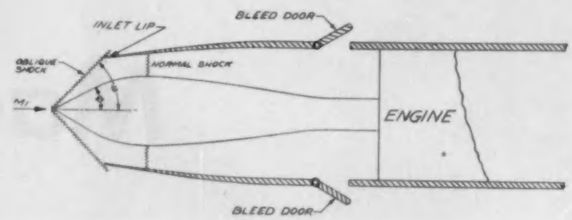


Fig. 1—Variable-geometry inlet for pod-mounted engine.

Inlet Operation

Three cases of inlet operation may be considered based upon position of the normal shock:

1. *Subcritical Operation*—If the normal shock is located in front of the inlet, air will be spilled around the inlet and the inlet will not capture the maximum mass flow possible. The spillage will cause drag, reducing airplane performance and the pressure recovery will be low, since the shock will occur at flight speed. For subcritical operation there is also a danger that buzz may occur. (Buzz is a flow instability during which the shock wave is alternately swallowed and regurgitated by the inlet at a frequency of 6 to 25 cps.) This buzz will cause violent fluctuations in pressure throughout the inlet and may result in damage to the engine or to the structure.

2. *Critical Operation*—If the normal shock is located inside the inlet at the minimum throat area, maximum pressure recovery is obtained, since the shock will occur at minimum flow velocity. For critical operation maximum mass flow is captured, and so drag is held to a minimum.

3. *Supercritical*—If the normal shock is located inside the inlet between the throat and the engine face, poor pressure recovery is obtained since the shock occurs at a point of increasing flow velocity. For supercritical operation maximum mass flow is captured, and so minimum drag is obtained.

Since the position and intensity of the oblique shock and the desired throat area are a function only of Mach number, it is possible to schedule the spike to the desired position for any airplane speed.

After the spike has been positioned, thus determining the throat area, the normal shock location is a function of flight attitude, Mach number, temperature, and engine operating condition. The location of the shock can be controlled on an open loop (scheduled) basis by setting the bleed exit area to a predetermined position for any combination of the control parameters. It is also possible to control on a closed loop basis by sensing the location of the normal shock and controlling the bleed doors in such a fashion as to drive the shock to the desired location.

Scheduled control requires a computer which will combine the varous control signals and set the position of the spike or bleed doors to whichever position is required. An extensive study of the inlet is also required to determine the interrelation between bleed area and shock position and between shock position and Mach number, temperature, flight attitude, and engine operating conditions.

Closed loop control requires an apparatus to sense the location of the shock and to determine when the shock is in the desired position.

(Paper "Supersonic Air Inlet Controls" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Machining by

Numerically controlled machines transform raw stock

IN the future, machining may be a completely automatic and operatorless process. The engineering drawing will be translated into a package of information expressed in the language of the machine's control system. When presented to the machine, this information will result in the production of a correct finished part.

The scope of a numerical system for machining extends from the engineering drawing to the machined, inspected part. Raw data storage is the first step in the system. Here the engineering drawing is described in numerical format. That is, arranged for unskilled, accurate entry of dimensions, tolerances, and so forth into a numerical data process. A manuscript is then developed. This contains all other necessary numerical data—the machine tool specifications, tool path and cutting sequences, work location on the machine table, feeds and speeds, and the combined skills of the planner, tool engineer, producibility expert, and of the machinist.

The machine instruction is set up by converting the planned manuscript numerical data into a punched tape or cards suitable to high-speed computer input. This is usually done by a standard electric typewriter with a tape punch attachment, a card punch, or a ten-key adding machine keyboard.

Processing Numerical Data

This numerical data is then processed (computation and interpolation) manually, mechanically, or electronically. The processing includes:

1. Calculation of discrete, progressive tool position points close enough to maintain tolerance.
2. Integration of angular relationships, particularly where cutter length varies the setback distance of the gimbal from the work surface.
3. Calculation of cutter-center-offset paths from the work face.
4. Interpolation of smooth curves from discrete position points.
5. Conversion of serial data, since it is received in serial order, into parallel data (multiple channels) with the introduction of a time base so that on and off circuits and one or more cutters may operate simultaneously in three or more axes.

Tool path storage (interpolated tool paths and other machine instructions) is the final data processing function and this is what goes into the shop to operate the machine tool. It is usually a multiple-channel magnetic tape but other media such as punched tape, punched cards, or photo-developed tape are used in a few systems.

Automatic Inspection

A feedback system is fitted on the machine tool, to sense independently the actual cutter position at all times, and, to compare continuously, the actual position with the instructed position. Any difference generates an error signal which the numerical control accepts as a correction factor. This is a form of continuous automatic inspection.

The use of numerical controls will probably result in a reduction in the number of holding fixtures required. The determination of what fixtures to use, however, will not be made trivial or arbitrary since it will be necessary to consider the effect of a particular choice of fixtures on the other aspects of programming and to avoid those choices which increase the other programming costs unnecessarily.

Specification of the sequence of operation and cuts will have to be done with an eye to minimizing the time on the machine. This should be fairly simple for machines which have a single cutting head and can position rapidly to the start of a cut. If the machine cannot position rapidly, it will be desirable to minimize the amount of positioning that must be done without unnecessarily increasing the number of cutter changes. Multiple-cutting-head machines will call for alternating the heads so that cutters can be changed in one head while the other head is working.

The advantages of numerical control show some radical improvements over present methods. A

Numbers

to finished part without the aid of a machine operator

Based on secretary's report by **M. C. Copold,** General Dynamics Corp.

standard numerical drawing and raw material blank were submitted for data processing with the following results:

Manual office paperwork	66.6%	reduction
Data processing	98.5%	reduction
Machining	75.0%	reduction
Boring	80.0%	reduction

Surveys by competent engineers and technicians indicate that despite anticipated problems, numerical control will yield high accuracy and much higher production in less factory area with less total equipment than present methods.

Numerical control of machining operations will also present a number of problems. Minimizing negative labor relations is a problem that will require early attention. The control systems associated with these new machines eliminate the requirement for a skilled machinist. In his place will stand a new species of machine operator who will mount tools, install and remove the workpiece, change tapes, and respond to other very specific, but simple, instructions. In the beginning there will probably be an operator at each tape controlled machine. As time goes by individual operators will probably take over the servicing of multiple machines.

Maintenance problems will demand early attention. Advanced training and system familiarization will be essential. This will be especially true of the early control units and associated machines. A well-conceived, efficiently-executed program of preventive maintenance, now generally desirable, will be a must for these new machines. Maintenance on a breakdown basis will be not only economically unwise but unworkable.

Work interchangeability between machines will present problems. Even with identical machines some problems may occur in regards to ability to interchange tapes due primarily to wearing differences between the machines. These problems can be kept under control by means of a test tape. Interchanging work between machines of basically different design but capable of performing the operations required presents considerably more complex problems. Response rates of servo loops must be comparable, static and dynamic errors must be closely comparable. These are elements that must be considered at time of acquisition of machines. Unless the specifications are drawn up with interchangeability in mind it will probably be impractical to effect interchangeability.

(This report together with 13 other panel reports of an SAE aeronautic production forum are available as SP-317 from SAE Special Publications Dept., 485 Lexington Ave., New York 17, N.Y. Price: $2 to members; $4 to nonmembers.)

Serving on the panel "Machining—Numerically Controlled" which developed the information in this article were:

A. E. Hill, panel leader
General Dynamics Corp.

R. L. Hand, panel co-leader
Lockheed Aircraft Corp.

M. C. Copold, panel secretary
General Dynamics Corp.

B. Gaeinnie
Northrop Aircraft, Inc.

W. D. Olsen
North American Aviation, Inc.

C. B. Perry
Douglas Aircraft Co., Inc.

More light thrown on auxiliary brake systems,

but basic question remains:

Which is the better . . .

Axle-by-Axle or Vehicle-

THE vehicle-by-vehicle versus axle-by-axle auxiliary brake system controversy rages on.

Proponents of the vehicle-by-vehicle system maintain in general that emergency features found in current braking systems with minor modifications and additions are adequate, that the few runaways that have happened have been magnified out of all proportion, and that in many such instances it was not the system, but the maintenance and driver's judgment that was at fault.

Advocates of the axle-by-axle system grant the many good features found in current brake systems and the substantial protection they afford. They grant, too, that many runaways could have been avoided by good preventive maintenance and better driver judgment, but that runaways are realities that must be reckoned with. They believe that the added braking capacity afforded by the axle-by-axle system is necessary to provide the maximum safeguard against runaway vehicles.

Table 1—Loss of Braking Capacity

Combination	Loss of Brakes on	Per Cent of Total Service Braking Capacity Lost	
		Axle-by-Axle	Vehicle-by-Vehicle
A	Tractor	56	56
	Trailer	44	44
B	Tractor	39	39
	One trailer axle	30	
	Both trailer axles		61
C	Tractor front axle and one of the tractor tandem axles	30	
	One of the tractor tandem axles	22	
	All tractor axles		53
	One trailer axle	24	
	All trailer axles		47

Table 2—Minimum Percentage Difference When Axle-by-Axle Protection Is Taken as 100%

Combination	Axle-by-Axle, %	Vehicle-by-Vehicle, %	Difference, %
A	100	100	—
B	100	64	36
C	100	68	32

Comparison between Two Systems

Comparison between the two systems concepts can be made by considering the three most commonly used air brake combinations. These are:

A. Two-axle tractor—single axle and semitrailer.

Brakes available, sq in.		
	Front	150
	Rear	410
	Trailer	435
	Total	995

B. Two-axle tractor and tandem axle semitrailer.

Brakes available, sq in.		
	Front	150
	Rear	410
	Trailer	435
	Trailer	435
	Total	1430

C. Tandem-axle tractor and tandem-axle semitrailer.

Brakes available, sq in.		
	Front	150
	Rear	410
	Rear	410
	Trailer	435
	Trailer	435
	Total	1840

The percentage loss of braking capacity in the event of brake failure would be equal with the two systems on the first combination, but in the case of the other combinations the advantages would lie with the axle-by-axle system, as shown in Table 1.

by-Vehicle?

Since axle-by-axle protection represents the most braking capacity that can be expected to remain in the event of loss of brakes somewhere on the vehicle because of a broken brake chamber hose or ruptured diaphragm, then the minimum percentage difference when axle-by-axle protection is taken as 100% would be as given in Table 2.

This table indicates that, when tandem-axle vehicles are involved as in combinations B and C, the axle-by-axle braking concept provides a much greater margin of safety than the vehicle-by-vehicle concept.

There is very little difference between the two systems in air application times or in stopping distance after a full-pressure service brake application.

Road Tests

These findings came from road tests of a two-axle tractor and tandem axle semitrailer equipped, first with a conventional system, then modified to provide the additional functions for axle-by-axle auxiliary brake protection. The initial road speed was 20 mph.

Stopping distances obtained from automatic application of the trailer brakes when the emergency line between tractor and trailer was disconnected (and without tractor brakes operating) was 54 ft with the conventional system and 121 ft with the axle-by-axle system. The large difference is not an inherent difference in the two systems, per se. The greater distance required to stop with the axle-by-axle system is the result of a delay purposely designed into the relay emergency valves to prevent a so-called "dynamite stop." If such a valve were to be used on the trailer of a combination equipped with an otherwise conventional brake system, under the test conditions the distance required to stop by that vehicle would also be stretched out. Similarly, use of conventional relay emergency valves on the vehicle equipped for axle-by-axle protection would appreciably reduce the distance required to stop on automatic application of the trailer brakes. (Incidentally, the valves with the built-in delay used on

The Authors

THIS ARTICLE is based on the following papers:

"Individual Axle Protection against Runaways"

by **John Thomas**
International Harvester Co.

"Individual Axle Protection System Test Results"

by **Stephen Johnson, Jr.**
Bendix-Westinghouse Automotive Air Brake Co.

"Individual Item Protection"

by **H. T. Seale**
H. T. Seale Co.

"Conversion of Present Equipment to System of 'Individual Vehicle Protection' "

by **W. L. Bennett**
Baltimore Transfer Co.

"Status and Interpretation of ICC Regulation"

by **B. G. Milster**
Bureau of Motor Carriers, Interstate Commerce Commission

Papers were given as a Symposium—**Emergency Braking Systems for Combinations of Commercial Motor Vehicles.**

(Papers on which this abridgment is based are available as a package in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N.Y. Price: $1 to members; $2 to nonmembers.)

the vehicle with axle-by-axle protection are strictly experimental and are not available to the public.) For these reasons, no arbitrary stopping distance requirement for the emergency system is practical.

Among other stopping distance test results obtained with the axle-by-axle system under various emergency conditions and with the vehicle combination loaded to 51,000 gtw were:

1. With 86-psi initial pressure, a fast leak was induced in the tractor reservoir. While maintaining 20 mph, 7½ sec after start of the fast leak the tractor protection valve had closed and the relay emergency valves started the building up of pressure in the trailer brake chambers. The stopping distance from this start of emergency brake application until the vehicle combination had stopped was 156 ft.

2. Under the same conditions as above (1), a slow leak was induced in the tractor reservoir. The stopping distance from the point of start of emergency trailer brake application until the vehicle combination had stopped was 154 ft.

Safety Equipment

There are many good items of tractor-trailer brake safety equipment available. Undoubtedly, they would come under the classification of vehicle-by-vehicle or conventional equipment, but they do enable a fleet to operate without serious accident.

A widely used and extremely important safety item is the low-air-pressure warning device. Another item is the one-way check valve, which is used quite generally between compressor and reservoir to ensure that all air in the brake system will not be lost if there is a failure of the line from the compressor to the brake application storage system.

The trailer emergency relay valve is also very widely used. Its purpose is to provide for automatic application of the trailer brakes should the trailer separate from the towing vehicle. Some of these valves have a no-bleed-back feature incorporated in their design so that the trailer air supply cannot be depleted except by a normal service brake application or by an emergency application. Without this no-bleed-back feature, a slow leak forward of the valve could cause the entire air system's supply to be depleted.

Some emergency relay valves have, in addition to the no-bleed-back feature, a restricted orifice in the supply line going to the valve. The restriction will protect those parts of the system not controlled by the particular valve, by limiting the input of air through the valve to a rate no greater than the compressor can provide normally. These later developments on the emergency relay valve have greatly enhanced its safety value.

The ICC regulation for a tractor protection valve gave manufacturers considerable latitude in the development of such valves. Some valves were designed to close the lines off automatically upon severance, while in other cases the use of a manual control was included in the valve design. One of the most widely used valves with manual control also incorporates a provision to apply the trailer brakes by opening the emergency line, thus throwing the trailer into the emergency application. By appropriate use of the manual control the emergency line can also be closed and recharged to release the trailer brakes.

This particular valve has an added safety feature. Should the air supply on the tractor fail and the driver neglect to use the hand control, the valve will automatically close off the lines when the pressure reaches a predetermined amount of approximately 24 psi. This means, of course, that with the automatic closing off of trailer lines the trailer brakes would then be thrown into emergency as well. The low-pressure warning device would come into play long before this condition developed, but should the driver disregard the warning, the automatic brake application would come as a final safety measure. Use of this type of tractor protection valve in conjunction with one of the trailer emergency relay valves, which has the no-bleed-back feature, provides an excellent safety combination. It assures the availability of a full tank pressure for the brakes when the trailer brakes are thrown into emergency.

It is highly important that an auxiliary means for controlling the brakes manually be incorporated in the braking system of combination vehicles. With this, the driver should have an opportunity to release the brakes after making an emergency application. The sudden locking up of brakes while proceeding in a line of traffic, at a traffic intersection, or on a railroad crossing, could in itself be the cause of a serious accident. The unwanted automatic application of brakes can be extremely hazardous, and this hazard can be doubled by the inability to release the brakes immediately. The automatic application of brakes as a last resort, as described in the previous paragraph, could be a real contribution to safety in cases where the driver would have ample opportunity to control the unit in normal conditions long before the need for an automatic application would arise.

Effectiveness of Emergency Features

Tests have been conducted to determine the effectiveness of some of these emergency features. All tests were run at 20 mph, using a tractor and tandem-axle trailer having a gross weight of 56,000 lb. The first runs were made with normal brake application and the combination vehicle was stopped in about 28 ft, as measured with a detonator. In the next runs when the hand control feature of the tractor protection valve was used, which means using only the trailer brakes, the stopping distance was approximately 56 ft. In this instance the service line to the trailer was shut off to ensure making the stop with only the air in the trailer reservoir.

In the third and final tests, only the tractor brakes were used. Controls to the trailer were shut off, and the trailer tank was bled down to be certain there was no air available. Again, stops were made in about 56 ft. These trials indicate that had brakes been used in the same manner on a grade, there would have been no runaway.

The need for good maintenance of the braking system on any combination of vehicles cannot be overestimated. No system is stronger than the maintenance provided. Therefore, because a simple system can be more easily maintained, the entire control system should be kept as free from complexities as possible. Intricate controls can easily defeat the purpose for which they are intended.

In view of experience with the many good items of tractor-trailer brake safety equipment perhaps it is more to the point simply to see that we have good protection for the combination units on the road, than to battle over the relative merits of the two brake system concepts.

ICC Regulation

In commenting on the proposed ICC regulation, section 193.53, one person has said: ". . . there is no known valve or device which will work properly and effectively comply with the proposed regulation without creating new hazards and problems . . ." All agree that this is true. The problem is too big to be solved by the use of a valve or device merely. The solution lies in a braking system carefully planned as to the relations and interactions of all its parts. Such a system may depart little or not at all from the system already in use on the individual vehicle, or it may depart radically, depending on the braking system on the individual vehicle and that on other vehicles in the combination.

Critics have stressed that the proposed rule would increase the possibility of malfunctioning because of the complexity of the system required. Some commentators have said a completely separate system for applying brakes in the event that the regular braking system fails should be acceptable as alternative to other provisions of the proposed rule. Others maintain just as emphatically that devices used only in emergencies are much more likely to be neglected as to maintenance than the devices they are intended to safeguard.

Spot checks have been made of 30 recent accidents involving vehicle combinations in which brake failure was alleged to have been a contributing factor. Of these, 14 should have been prevented if proposed rule 193.53 had been in effect and observed. Ten accidents might or might not have been prevented, while the remaining six would not have been prevented.

A vehicle-by-vehicle approach has been urged as an adequate solution to the problem, provision to be required such that failure of brakes on either towing or towed vehicle would not render the brakes on the other vehicle inoperable. Specifically, the Bureau of Motor Carriers has been urged to recommend to the Commission certain amendments to the Motor Carrier Safety Regulations based on the following five points as regards air brakes, suitably modified for brakes on other types as appropriate, in which a towing vehicle may be either a truck or a truck-tractor, if used to tow a trailer required to be equipped with brakes, and a trailer may be any form of semitrailer, full trailer, or pole trailer, when required to be equipped with brakes:

1. Equipment of each towing vehicle (not those made after June 30, 1953, merely) with means for keeping its brakes operative in the event of breakaway.
2. Equipment of each towing vehicle with means for activating emergency features of the trailer brakes manually.
3. Equipment of each towing vehicle with means for automatically applying the trailer brakes in the event of serious depletion of the power for operating power brakes.
4. Equipment of each towing vehicle with means for preventing loss of brake power in the event of failure of the connection between reservoir and power source.
5. Equipment of each trailer with means for preventing loss of air from the reservoir by backflow through connections with the towing vehicle.

Several advantages are claimed for the amendments. They could be made effective at an earlier date than the originally proposed rule 193.53. The braking systems so required would be simpler, more reliable, and less burdensome to carriers as regards cost and maintenance, while affording the protection sought to a substantial degree. On the other hand, the principal advantage of a braking system complying with rule 193.53 would be that in the event of part failure, more of the brakes on the combination would remain effective and subject to better control by the driver. This appears to be especially important for relatively heavy (multiple-axle) trailers, and on slippery roads.

Since the modifications of regulations do not bear on the question of brake performance in the usual terms of feet to stop from specified speed, tests to establish the practicability of compliance with new or proposed regulations should not include deceleration tests. Instead, they should comprise timing tests, probably by electrical means, to ascertain the time from the moment the driver's foot touches the pedal to the moment the brake cylinders or chambers come to full travel at standard operating pressures, such as 60 psi (air), 15 in. of Hg (vacuum), or 1500 psi (hydraulic).

Such tests should be made before and after remodeling the brake system to comply with the new or proposed rule (where remodeling is necessary) as a check against claims that compliance interferes with normal service brake action. They should be repeated after a considerable period of regular commercial service, with standard maintenance as practiced by the vehicle owner, with careful recording of all work done to the brake system. The last set of tests should include such simulated part failures as can be agreed upon.

ICC Regulations Amended

THE accompanying story is based on papers presented while the pertinent ICC Regulations were still pending.

The following remarks by Carl C. Saal, chief, Vehicle Operations Section, Bureau of Public Roads, and chairman of the session at which the papers were given, tell what has happened since:

"The discussion of ICC Regulation leaves the impression that adoption of either the proposed section 193.53 or a proposal based on the vehicle-by-vehicle concept is still pending. However, ICC has adopted measures which are practicable but less stringent than 193.53. Effective June 30, 1956, sections 193.43, 193.50, and 193.51 of the Motor Carrier Safety Regulations were amended to provide added safeguards against parts failures in motor vehicle braking systems. The revision of 193.43 provides for vehicle-by-vehicle protection of the braking systems and the use of no-bleed-back relay emergency valves. The revision of 193.50 requires use of a check valve between the source of compressed air or vacuum and the reservoir on the tractor, and the revision of 193.51 requires use of a low-vacuum warning device on trucks and truck tractors used for towing vehicles equipped with vacuum brakes.

"Although the provisions of the regulations adopted by ICC provide a somewhat lesser measure of brake reserve than the original proposal, they do represent a substantial and worth-while forward step in putting into the hands of the motor vehicle driver the means of bringing his equipment to a stop after a failure of some part of the braking system. The system adopted has a number of very important advantages at least equal, and in some respects superior, to those which would result from the orginal proposal.

"In order to evaluate more fully the relative merits of the two concepts of brake protection the Bureau of Public Roads, in cooperation with and at the request of ICC, is conducting a comprehensive study of emergency braking systems. Results of the tests will provide factual information on which the Bureau of Motor Carriers can base additional revisions of their safety requirements for brakes as they become necessary or desirable."

Experience Gives

13 Answers

to Current Heat-Treat Questions

Based on secretary's report by **D. J. Wulpi,** International Harvester Co.

This article distills practical information for immediate use by engineers from the experience of these seven men and their audience at the panel on Heat Treating Techniques at an SAE Tractor Production Forum:

J. D. Graham, International Harvester Co., chairman

D. J. Wulpi, International Harvester Co., secretary

J. H. Clark, International Harvester Co.

N. K. Koebel, Lindberg Engineering Co.

H. J. Bates, Fairfield Mfg. Co.

M. L. Frey, Allis-Chalmers Mfg. Co.

S. L. Henry, A. O. Smith Corp.

Q. How close can carbon restoration be controlled.

A. Carbon restored stock purchased from the mill usually has a considerable maximum surface carbon content above that of the base metal. For example, in SAE 1045 steel the maximum surface carbon content may be eutectoid. Closer control is not now possible with the large loads used in mill production.

In any case, the maximum carbon content must not be less than that of the original stock. With smaller furnaces and smaller loads, carbon restoration can be controlled to closer limits with proper atmosphere control. The depth of carbon penetration must be such that no location has a carbon content less than that of the base metal.

Q. Are seams and other surface defects any worse in carbon-restored bars ....

A. No. The surface condition of carbon-restored bars is about the same as for any cold finished bars. If the material is to be locally hardened (as by induction or flame heating), the mill may pay more attention to surface condition if its ultimate use is known. Danger of cracking due to surface defects may be somewhat lessened by stress relief prior to hardening.

Q. In carbonitriding, how can the white layer and microcracking be eliminated ....

A. By avoiding excessive carbon *and* nitrogen content of the case, the white layer can be minimized. If left at heat for a long period of time, the nitrogen content in particular must be controlled. One method found satisfactory in controlling the case is to carbonitride, aircool, reheat in a neutral bath, and hot quench.

Apparently, coarse grain is the major cause of microcracking in carbonitriding. It is independent of the method of quenching. Microcracking may be damaging in fatigue, although no known failures have been attributed to it.

Q. How can distortion be minimized in stampings case hardened to Rockwell C 60 ....

A. By controlling the quality of raw material from the source so that differential hardening, giving distortion, does not result. Killed steel is generally desirable for this purpose.

Another way is to relieve, prior to heat treatment, stresses resulting from stamping. This can be done by overheating the stamping in a fixture so that it will hold its shape better when case hardened.

Carbonitriding should be performed at 1550 F, dropping the temperature to about 1450 F before quenching.

Distortion may also be minimized by clamping the part in a fixture prior to hot oil quenching, but after carbonitriding to the desired case depth.

If sufficient nitrogen is present in the case, it may be possible to use an air or atmosphere quench to successfully harden the surface. However, if this is done, the case will be very superficial on low-carbon stock.

Q. What is bright hardening and how is it achieved.

A. Hardening to produce clean surfaces, free from oxide or carbonaceous products, is known as bright hardening.

The entire heat treating operation must be carefully controlled to avoid formation of these undesirable products. The part must be clean and free from oil when put into the surface. Tight furnace construction avoids infiltration of air, which would oxidize the surface.

Important is a closed quenching system, and maintenance of a neutral atmosphere above the quench tank to avoid oxidation of oil and contamination with moisture. Rapid oil agitation reduces the possibility of oil breakdown by the hot parts, particularly when large masses or heavy sections are being quenched. Good oil filtration systems should be used to maintain oil cleanliness.

Under optimum conditions, the appearance of the hardened part should approximate its appearance before heat treating. The appearance may gradually darken as the oil becomes contaminated over a period of time.

Q. Can the same quenching oil be used at low temperatures as well as up to 300 F ....

A. Special oils, made for variable temperatures, should be used where the oil temperature is to be varied. It may be necessary to adjust agitation to compensate for changes of quenching power as affected by oil viscosity.

Q. Is it necessary to temper carburized helical and spiral-bevel gears quenched in hot oil (250–350 F).

A. Tempering or stress-relieving of constant-mesh gears is often unnecessary. However, careful control of core hardness and case depth must be maintained to avoid undesirable residual stresses. If shock loading or clashing is encountered in service, tempering in the 325–425 F range is advisable.

Q. How can an internal spline in a disc be hardened to Rockwell C 40–45 without distortion of the disc. (The disc, which must be made of Armco iron for its nonmagnetic properties, is about ¼ in. thick and has a 1½ in. pitch diameter internal spline.)

A. Before any hardening can take place, it is necessary to have a carbon buildup on the areas to be hardened. This may conveniently be done by carbonitriding while protecting the areas not to be affected.

It may be desirable to use an oversize broach to compensate for bore shrinkage if the change is uniform. Or, when quenching after carbonitriding, it may be convenient to quench on a splined plug,

possibly in a flat quenching die fixture to maintain shape. If the desired hardness is not achieved, the spline can be induction hardened while rotating the disc during heating and during an integral spray quench. This procedure will help to give uniform heat and hardness distribution.

Q. How can steel castings be heat treated for optimum machinability when the analysis corresponds approximately to SAE 8620 ....

A. Low carbon, low alloy steels should be normalized with a fast air-cool to give a fine pearlitic structure. Large ferrite areas are usually detrimental to good machining because of tendency to be "gummy." It may be necessary to temper large pieces after normalizing to reduce the hardness of projections and corners, because these may have cooled faster and thus become somewhat harder than the main body. Mechanical factors, such as sand, may be detrimental to machinability of castings, but metallurgical principles are similar to those of wrought steels.

Q. How does the load carrying capacity of induction-hardened gears compare to that of carburized gears.

A. At a given hardness level, properly made induction-hardened gears have about the same load carrying capacity as carburized gears.

Q. How can dimensional control of plain carbon induction-hardened bull gears be maintained ....

A. Design is a most important factor. It is easier to control dimensions where the gear is heat treated separate from the hub, or carrier, than when the gear is integral with the hub. Also:

- A symmetrical cross section tends to reduce trouble from taper.
- Heating and quenching must be uniform on the gear to equalize residual stresses. Either water or oil quenching may be used, depending upon the gear size and the steel used.
- Preheating prior to induction hardening is frequently used for dimensional control.

Q. How can retained-austenite be minimized in SAE 1024 steel (1.35–1.65% manganese), carburized and direct-quenched ....

A. Drop the temperature to 1525–1550 F from the carburizing temperature before quenching.
It is possible to refrigerate the part to transform more austenite but this is usually impractical in production. Also, excessive surface carbon concentration should be avoided.

Q. How can a maximum case-carbon content below 1% be maintained in continuous carburizing ....

A. Diffusion zones in the furnace are necessary to properly reduce the surface carbon content.
The furnace design is very important. If separate zones of atmosphere cannot be maintained, difficulty will be encountered. Long, narrow furnaces are best suited for this purpose.

The first zones must be rich in carburizing potential while the last, or diffusion, zones must be lean to enable the carbon buildup to penetrate deeper into the steel.

(This report together with 7 other panel reports are available in full in multilith form as SP-316 from SAE Special Publications Dept., 485 Lexington Ave., New York 17, N. Y. Price: $1.50 to members; $3.00 to nonmembers.)

Jets will compound ground handling chaos unless we . . .

Lockheed Aerobridge propels itself into position and adjusts to airplane door height for rapid conveyorized loading.

Modernize Terminal Facilities

Based on paper by **H. O. Olson,** Douglas Aircraft Co., Inc.

TO be as modern and efficient as the planes they will serve, passenger gate positions at terminals serving jet airliners may require:

1. Fixed installations for fuel, air conditioning, and auxiliary power.

2. Sheltered entry for passengers.

Concentration of mobile serving equipment at gate positions causes congestion. The obvious way to reduce the congestion is to substitute fixed installations for this mobile equipment. Most of it could be eliminated.

Fueling is a problem of material handling—of moving a volume of liquid from a point of storage to the gate position and into the airplane tanks. Small quantities are best handled by truck; large amounts by pipeline. Hydrant and pit systems are in use and the throughput is justifying the investment. The saving in fueling time, permitting short en route stops and more rapid turn-arounds, is a definite value. Removing the tank trucks from the traffic pattern at the gate position is a great convenience. Hydrant systems should be more widely used today, and for the turbo transports of tomorrow they are a must.

Electrical Power Requirements

The coming aircraft will require as much as 150-kva capacity, 400-cps, a-c current at the gate position. Fixed installations for d-c supply have proved economical. The modern gate position must provide for both a-c and d-c supply from remote generators. Whether the current comes from a central generating source at each concourse or from individual units at each gate is for the electrical engineers to decide. A limited number of outlets per generator will probably be the answer.

At the Amon Carter Field at Forth Worth, an underground manifold system delivers precondi-

tioned air to each gate position. The system ties into the terminal building heating and cooling system. It is extremely reliable, requires little maintenance, and can be attached to a plane seconds after it has arrived at the gate position.

Large aircraft are requiring approximately 25 tons of refrigeration. Engineers have estimated a cost of $1200 per ton per gate position for an installation comparable to that at Amon Carter. This would include a proportionate part of the central refrigeration and heating equipment which furnishes the chilled water and steam to the heat exchangers. The cost can be justified and the ramp is free of another mobile unit.

Pneumatic Power

Jet transports are going to require pneumatic power. This could be supplied through a manifold system to the gate from a central receiver-tank or accumulator charged by a standard shop supply air compressor. Such systems are currently used at aircraft and jet engine plants. The installations are reliable, low in maintenance, quiet in operation, and the initial cost is below that for portable equipment.

As part of fixed installations at each gate position there should be a sewage system replacing portable carts. Here it will be necessary to provide hot water for septic tank flushing and replenishing with the necessary liquid, all of which could be incorporated in a pit on the ramp.

Powered conveyors to carry luggage from the airplane to the baggage claim areas are essential for the modern terminal. Unless a terminal is planned so that baggage claim areas are reasonably near gate positions, such a system would be very complicated. Properly designed conveyors can also be used to emplane baggage.

Even with fueling, air conditioning, and auxiliary power supplied from fixed positions, and baggage handled by conveyors, there will still be some mobile equipment needed. There will be commissary trucks, trucks with cabin cleaning supplies and materials, and freight, express, and mail.

Sheltered Passenger Entry

Once a fuel hydrant system is installed, and other services are supplied from fixed positions at the gate, an airplane must be brought into that gate position and spotted with reasonable accuracy. With this done, the way is open to provide sheltered passenger entry with a minimum of cost, and at the same time do away with another piece of portable equipment —the passenger stairway.

The airlines have been searching for a solution to the entry problem for more than 10 years, and several ideas have been developed. There is the Whiting Loadair installed at New York International Airport which pulled the airplane sideways to index the passenger door with a fixed platform which was roofed over and connected to the concourse by a passageway. The concept could be incorporated into a general airline terminal plan.

Another method is to use a canopied bridge structure that reaches out from the concourse structure to the passenger door after the airplane has been spotted. Basically, this is the Lockheed Aerobridge now being service-tested at Travis Air Force Base as a means for bridging the gap between freight terminal and cargo plane for the fast, efficient movement of cargo. At O'Hare Airport in Chicago, this concept was kept in mind in designing the concourse of the terminal building.

Nose Dock Entry

In 1945, Albert F. Heino, a United Air Lines architect, recommended at an SAE meeting in Chicago that the airplane be positioned in a nose dock to facilitate sheltered entry. The proposal required that the passenger door be placed in the forward end of the plane cabin. No such door location was contemplated at the time and the idea was ridiculed. Today, airplanes with this feature are in service and the turbo airplanes now being built will have this accommodation. In planning for sheltered entry, this far-sighted architect's idea must now be given thorough consideration.

(Paper, "Planning for Handling Jet Transports at the Passenger Terminal," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Based on Discussion

E. F. Zimmerman,

Shell Oil Co.

IN some instances fueling by truck is cheaper than hydrants and operationally acceptable. In others, fueling by truck is acceptable now, but a later increase in traffic would require use of hydrants. In either case, fueling facilities can be developed in phases as follows:

1. Install initial fuel storage with a truck loading rack not too remote from the passenger terminal. Fuel with trucks, using this storage area for filling.

2. When increased throughput will justify the expense, construct additional fuel storage, pipelines, and satellite tanks which should be located as near to the passenger terminal as is acceptable. The truck loading rack should then be moved to the satellite tank area. Fuel by truck, but fill them at the satellite tank loading rack.

3. When the expense can be justified, construct pipelines from satellite tank area to the gate positions and install hydrants. Fueling will then be performed by hydrant carts.

Phase development should result in installations being made when and if required. This will obviate the risk of making installations which will have to be paid off before traffic will bear it.

How Ford Met the Challenge of Severely Offset Hypoid Gears

Based on paper by **Bain Griffith,** Ford Motor Co.

CAN severely offset hypoid gears be made commercially? Will they be adequate in an automobile?

Ford's answer is "Yes." The affirmative answer results from calculations, tests, and service experience related to Ford's new 1957 rear-axle design.

Design of the hypoid gears was the most challenging problem in developing this new unit, which has a straddle-mounted pinion. Also incorporated is a 2¼-in. pinion offset, a 2- instead of a projected 3-jointed driveshaft, and a new housing designed for flexibility and maximum manufacturing economy.

Part of the gear problem arose from the wide range of gear ratios with acceptable noise characteristics required (from 2.9/1 to 5.8/1).

Besides, increased pinion offset from 1½ in. in 1956 to 2¼ in. in 1957 was a new problem in a new territory. To understand it, Ford engineers had to recall that all gears slide to a degree in profile action. Also, that hypoid gears slide along their face. Extreme-pressure lubricants are mandatory to successful performance. Scoring or welding (caused by lubricant being wiped clean of the tooth surfaces) is of extreme concern.

Hypoid gears produced in quantities usually have a 45- or 50-deg pinion spiral angle . . . and the offset angle, or difference in spiral angle varies from 10 deg in truck applications to 25 deg for passenger cars. The tangent of 50 deg minus the tangent of 25 deg has been generally recognized as the maximum successful endwise sliding factor in commercial experience. It has been generally assumed that to exceed this quantity when using commercially available lubricants might produce scoring.

Slide components not exceeding this quantity with 2¼-in. offset gears dictated a maximum pinion spiral angle of 40 deg—and about 5 deg on the gear.

With this as a starting place, Ford designed the gears in a ratio of about 3/1 and 4/1, as design-scheme trials.

Next, the variation in pressure angle in the two sides had to be properly established. (Hypoid gears "lean over," and gear-cutting is a real question because the "leaning over" condition becomes substantial as the pinion offset increases.)

Fig. 1 makes clear that, in the pitch plane, gear and teeth are moving in two different directions at the same time. The tops of the pinion profiles on the drive side are engaging larger gear-tooth elements as they roll out of mesh. Conversely, the profiles have to shrink on the coast side, going out of mesh in reverse rotation.

The instantaneous rate of change in size of tooth profile establishes the so-called "limit pressure angle" so much talked of in hypoid gears. This is the quantity which must govern the "lean-over" of the teeth. By merely changing the pinion offset, other things remaining equal, the limit pressure angle increases rapidly.

Fig. 2 is a "virtual" section of the pinion tooth. The radial distance to the inner ends of the two pinion profiles is about equal if the projection of the pressure angles themselves are equal from the projection of the limit pressure angle. The maximum depth of a pinion tooth from the pitch joint that will develop no undercut on either profile can be determined with fair accuracy. This undercutting condition will not necessarily remain constant from end to end across a relatively long tooth face. But gear teeth can be designed on this basis which

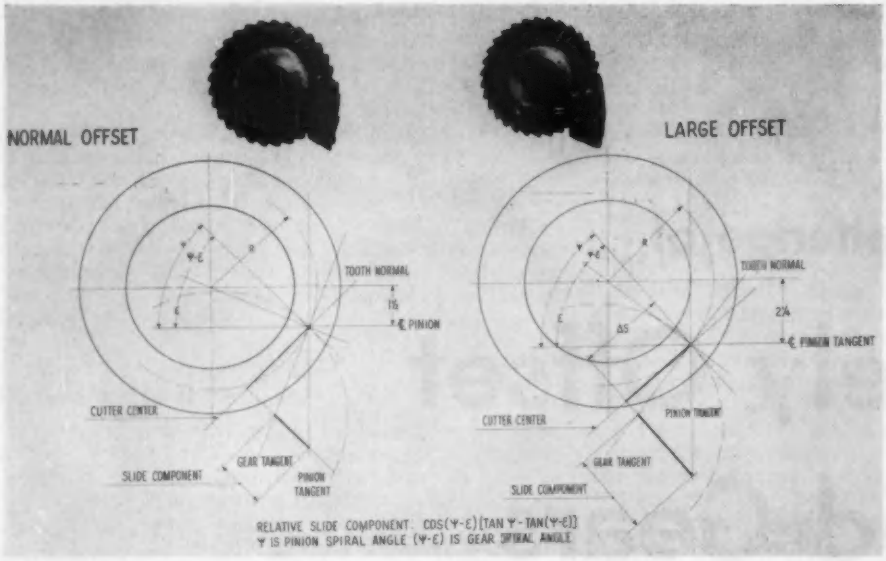


Fig. 1—Relative slide component — hypoid gears. In pitch plane, gear teeth are moving in two directions at the same time.

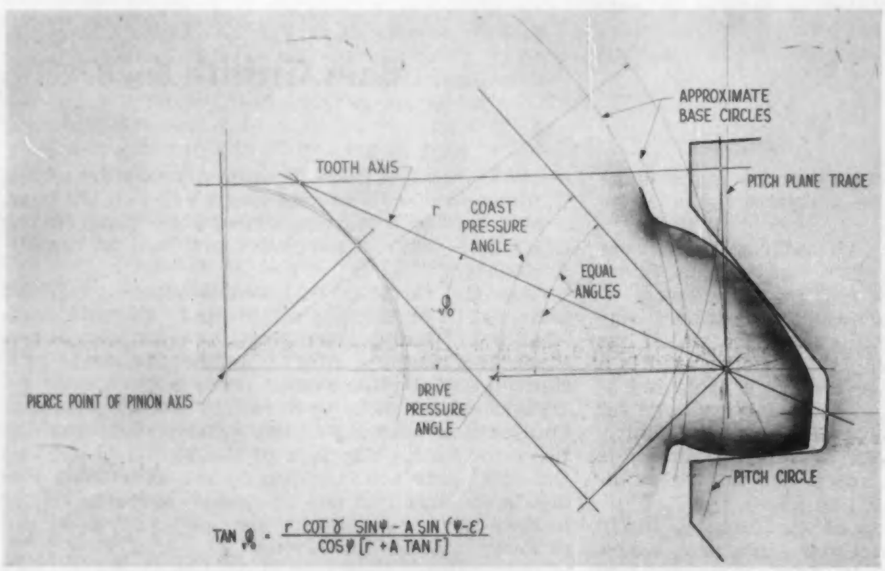


Fig. 2—Transverse pinion profile showing tooth axis. Radial distance to inner ends of two pinion profiles is about equal if projection of pressure angles themselves are equal from projection of limit pressure angle.

can be expected at the outset to be reasonably free from undercut.

The first gears that looked right and rolled well were designed with the 40-deg pinion spiral angle. But lack of tooth overlap was evident with noise and roughness.

At the earnest suggestions of Ford's gear development people who have to maintain the quality in production, new gears were designed to the conventional scheme of 50 deg on the pinion and about 15 deg on the gear.

The endwise sliding was expected to be disastrous. However, from the cutting standpoint, these designs were entirely satisfactory. In the gear laboratory, they looked right and sounded right, and they reacted to manufacturing methods of long-standing. These were gears that could certainly be made commercially.

Scoring was expected to be the major problem, but dynamometer efficiency factors of 96 and 97% are identical in axles with normally offset hypoid gears or bevel gears.

An indication of the effect of tooth pressures and endwise sliding velocity was obtained by comparing assemblies of known characteristics. Finally, it was concluded that the increased rate of endwise slid-

ing of the teeth was not the problem it had been presumed to be.

Performance with sustained high speed was checked with automobiles driven at an average of 95 mph, 85 F ambient air temperature. After a few laps of the track, oil temperature stabilized at 195 F, which is lower than the temperature of many axles of conventional design. Furthermore, in Ford's dramatic and widely publicized "Operation Left Turn" the 1957 axles withstood the continuous high-speed operation, evidenced no distress, and remained entirely serviceable after being removed from the test cars.

Ford's 1956 assembly weighed 57 lb and the 1957 assembly weighs 65 lb; all but ½ lb is directly attributed to the increased offset in forging and casting requirements. The range of gear ratios is also much broader. Minimum competition weighs 64.25 lb and the balance of 1957 production in the field range heavier, to 80 lb.

There are currently in production 16 different ratios with no change in gear mounting distance. All ratios are interchangeable in the same differential carrier with the same differential case. Spiral angles on the gears, however, vary from 45 deg on the fastest ratios to 60 deg on the slowest. Table 1 indicates the design quantities of the entire range.

(Paper, "Design Features of the New Ford Axle," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Table 1—Design Values—1957 Ford Axle Gears
(8.75 P.D. GEAR, 1.375 FACE, 2.25 OFFSET DOWN)

	Ratio	No. of Pinion Teeth	No. of Gear Teeth	Pinion Spiral Angle	Gear Spiral Angle	Torque Input, lb.-ft.	Pinion Rpm
Series I Regular Production	2.91	11	32	47° 30′	15° 21′	970	500
	3.10	10	31	50°	17° 19′	970	500
	3.22	9	29	50°	17° 2′	970	500
	3.56	9	32	50°	16° 21′	875	500
	3.70	10	37	50°	16° 7′	840	500
	3.89	9	35	50°	15° 47′	840	500
	4.11	9	37	50°	15° 30′	730	500
Series II Special	3.40	10	34	50°	16° 38′		
	4.29	7	30	55°	20° 14′		
	4.57	7	32	55°	19° 57′		
	4.72	7	33	55°	19° 45′		
	4.86	7	34	55°	19° 38′		
	5.14	7	36	60°	24° 7′		
	5.43	7	38	60°	23° 57′		
	5.67	6	34	60°	23° 50′		
	5.83	6	35	60°	23° 46′		

Series I includes dynamometer loading; average life exceeds 1,000,000 pinion cycles.

Best Fuel Economy . . .

. . . of diesels was obtained with poorest quality fuels, but excess exhaust smoke and other problems arose, in recent tests. There is need for further study, the authors say.

Based on paper by **J. M. Sills and W. A. Howe**
Greyhound Corp Gulf Oil Corp.

A Greyhound-Gulf study on the effect of diesel fuel characteristics on power, acceleration, economy, and exhaust smoke indicates that:

1. Maximum horsepower is obtained on the poorest quality fuels, that is, those having low volatility and low cetane index. The use of such fuels would, however:

(1) Result in premature overhaul.

(2) Promote excessive exhaust smoke.

Thus, it is doubtful if this type of fuel can be recommended for continuous use, partciularly because of its low cetane index.

2. Acceleration is more a function of driving habits than fuel characteristics—despite reports to the contrary. Between eight fuels of widely varying characteristics the coach using the apparent fastest fuel could not pass the coach using the slowest fuel in less than 15 sec. All eight fuels reached ⅛ mile within 1.34 sec and ¼ mile within 2.0 sec. In four consecutive tests on the same fuel the results showed that 20 sec would be required for one coach to pass another and that on these four tests ⅛ mile was reached within 1 sec and ¼ mile was reached within 1.7 sec. If the acceleration tests showed any advantages between the fuels both in time and distance, it was in favor of those fuels with the 625 F end point and 44–51 cetane index.

3. Best fuel economy at full-throttle operation, as with maximum horsepower, was obtained with the poorest quality fuel. The same remarks concerning the use of such a fuel to obtain maximum horsepower apply also in trying to obtain maximum full-throttle economy. It would appear that fuels of 44–51 or 52 cetane index and 625 F end point give the best practical full-throttle economy. It also appears that optimum part-throttle economy can be obtained with fuels of 44–51 cetane index and with a 625 F end point.

Thus, to put it briefly, gravity or Btu's per gallon,

cetane index, volatility, and viscosity apparently have an effect on fuel economy. It is quite possible that a formula using these characteristics, and also perhaps utilizing the aniline point, could be devised by which operators could determine, from physical inspection of the fuels, which would give the best economy both at full and part throttle.

4. Exhaust smoke: The lower the cetane index and the lower the volatility of the fuel, the greater the tendency to increase the degree of smoke intensity, except that cracked stocks of similar volatility give smoke intensity in excess of their apparent physical characteristics. Exhaust smoke has been shown to increase with the amount of fuel injected, based on tests using various sizes of injectors but regardless of the characteristics of the fuel and the amount of fuel injected, smoke intensity begins to start accelerating between 600 and 625 F end point. It further appears that the use of a cetane-number improver does not improve smoke characteristics but, on the contrary, seems to degrade these characteristics to some small extent.

These test results were obtained with a GM coach powered by a Detroit Diesel model 6-71 rebuilt engine. Twenty-seven test fuels were used, 25 were straight-run and two were 100% catalytically cracked fuels. Cetane number ranged from 34 to 65. A cetane improver was added to one group of fuels.

Power and economy results were obtained by full- and part-throttle dynamometer tests at 45 mph. Acceleration tests were made on a level 4- and 6-lane highway outside the city limits. An accelerometer was used to measure acceleration. A tape-recording smoke-meter was used to give a smoke trace for each test.

(Paper, "Some Fuel Characteristics which affect Diesel-Engine Economy" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Aircraft Instrument Panels . . .

. . . coated with epoxy resin and edge-lighted, increase image legibility and resist scratches, discoloring, delamination, and damage from cleaning solvents.

Based on talk by **W. R. Adams,** Naval Air Station, North Island, California

AN improved method of applying epoxy resins to edge-lighted aircraft instrument panels has been developed by the Naval Bureau of Aeronautics. The new process facilitates sharper reproduction of white show-through images on a black background. It increases resistance to scratching, allows cleaning of panel with solvents without damage to panel images, and prevents discoloring of white images and delamination.

Specific advantages of manufacturing epoxy-resin-coated edge-lighted panels are as follows:

Six- or eight-point lower-case condensed italic lettering may now be used. *Previously,* sharp corners and thin lines were difficult to obtain. It was impractical to produce clear registration in smaller than 12-point capitals. Screening of a repellent through metal mesh limited reduction possibilities, making it difficult to reproduce 16-point lower-case closed shapes such as a, g, m, and z.

Fewer critical operations are required to apply the the image properly. A single piece of artwork is adequate for producing satisfactory images by a spray-through-screen technique. *Previously,* panel images were obtained by the questionable use of the reverse image. They were often the product of photographic or screened images overlayed with a clear vinyl laminate which tended to yellow under humid conditions, or when exposed to ultra-violet rays. At times, inefficient machining operations were used to apply images.

The repellent recommended for maintaining the white panel image is Cat-L-Ink Resist 50-115. It prevents adhesion of the black-pigmented epoxy-resin top coat to the white image area. A product of the Warnow Process Paint Co., Cat-L-Ink permits direct screening of image.

Mesh marks no longer exist to cause irregular or deceptive line widths. The use of 200–250 mesh metal screens is recommended to insure thicker deposits and better curing for higher durability.

Epoxy Resin and Repellent Application

Application of epoxy-resins and repellent to the panel involves the following main steps. (1) Clean panel properly. (2) Apply flat white-pigmented epoxy resin to all surfaces of panel, then cure. (3) Screen repellent through metal mesh to area where image is to be maintained. (4) Apply black-pigmented epoxy-resin top coat to all surfaces of the panel. (5) Repeat steps 2 and 3 if desired or as needed. (6) Develop white image by submersion of panel in aliphatic naphtha.

Passing of Qualification Test Anticipated

Qualification test panels covering the procedures outlined above have not yet been prepared for the National Bureau of Standards because of the limited time since development of the repellent described. But no essential change has been made in the materials composing the finished panel since a similar previous report was submitted in January 1956, so qualification is anticipated.

(This abridgment is based on a talk given at a Plastic Lighting Panels and Dials Committee meeting of SAE's Special Aircraft Projects Division.)

ORION

Gas-Generator Turbocompound Engine

Provided Unusual Development Problems

Excerpts from paper by **Ralph J. Hooker,** General Electric Co.

THE ORION is an entirely new powerplant. Thus it is no wonder that its development presented the engineers with many unusual problems to solve. Only a few will be discussed here. These are concerned with:

1. Cooling of cylinders and exhaust port bridges.
2. Cylinder design.
3. Piston design.
4. Fuel-injection system.

Cooling

With the specification of aircooling it was considered worth while, in the light of reliability and life, to use a larger percentage of "pneumatic" transmission and reduce the bmep. (To balance the engine and compressor power a higher bmep is required with fan cooling.) In addition, if the heat picked up by the cooling air could be made to do work on the turbine blades, then a certain credit could be given to the heat balance over the engine. This is the regenerative cooling idea; the heat picked up from the cylinder walls just about balances out the losses in pressure drop through the fins.

Because cylinder cooling was such a controversial question several tests were made to verify the heat-transfer calculations as well as to measure the pressure drop and to demonstrate the streamline pattern.

The next area that was considered vital to the life expectancy of the engine, due to high temperature, was the exhaust port bridge. These temperatures tested out at about 500 F. To have an alternate, various cooling schemes were laid out and several were tested on a single-cylinder engine. In one of the first successful schemes air was blown into the port cavity through the small drilled holes. The air displaced the hot gas from contacting the port walls as well as absorbing heat from the port and cylinder wall. When the engines first started, the fuel consumption and the exhaust temperatures were high. As a consequence, the port temperatures were also high, which was of some concern. How-

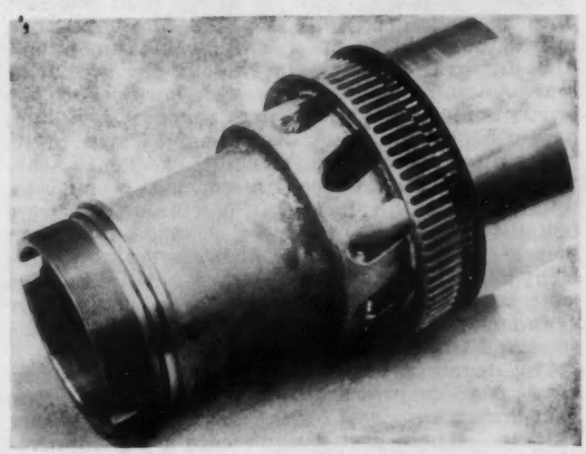


Fig. 1—Port and fin design finally adopted.

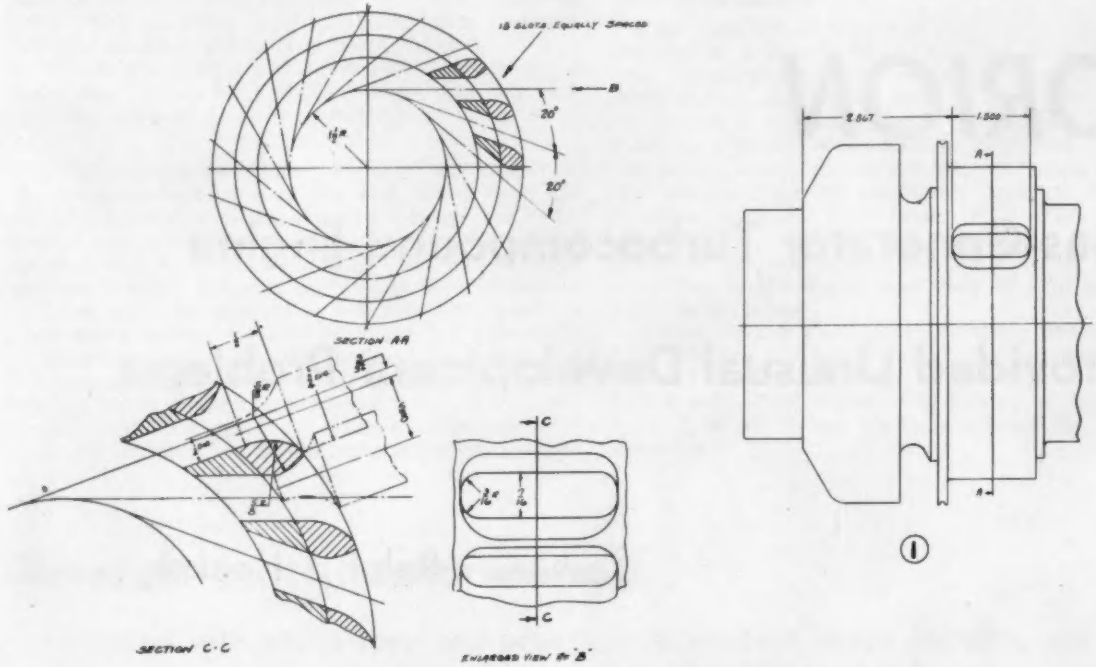


Fig. 2—Tangentially ported all-steel cylinder, which proved to be best port design.

ever, as soon as the sfc began to improve, the bridge temperature also came down, with the result that this cooling method was discarded. The port and fin design adopted as final is shown in Fig. 1.

Cylinder Design

The first cylinder designed was a one-piece steel sleeve with shrunk-on cooling fins. The scavenge ports were drilled for a double swirl.

It was immediately apparent that the one-piece cylinder was too costly for our development programs. Therefore, to increase the availability and reduce the cost, a 3-piece construction was developed. In this cylinder an Al-Fin muff was cast onto the cylinder sleeve and the fins were then milled into it The fin spacing is 0.145-in. pitch × 0.050-in. fin thickness. The two end pieces, that is, scavenge and exhaust halves, were shrunk into the center finned section, which is made of beryllium copper. This material was chosen because of its high-temperature strength and excellent heat-transfer qualities. The fin spacing is 0.100-in. pitch × 0.040-in. fin thickness. The three pieces were bolted together by the slender tie-rods made from bicycle spoke material. The shrink forces were sufficient to hold the cylinder together, but the tie-rods were an additional safety measure. All of the early cylinders were porous chrome plated until the all-steel and the ductile iron cylinders were made.

The double swirl was not satisfactory as far as combustion or pressure drop was concerned. The next port drilling was for the single swirl and other variants. These port designs were a big improvement over previous ones.

The Al-Finned cylinders with porous-chrome-plated bores were requiring too long a time to manufacture. It was decided to investigate the all-steel cylinder, made of 4140 steel and heat-treated to R_c 35. This design was of the same essential dimensions as the Al-Finned cylinder, except that the fins were milled from the solid steel. The earlier cylinders did not have bridge cooling. However, exhaust port bridge cooling was of great concern, so a special cylinder with cooling fins on the port bridges was made. The exhaust port bridge temperatures were not as high as expected and consequently this cylinder was never run.

Tests demonstrated that the engine needed two things: first, single swirl and secondly, low pressure drop. Consequently, the next cylinder design was a tangentially ported all-steel cylinder, as shown in Fig. 2. This proved to be the best port design, therefore other methods of manufacture could now be devised.

Since the beginning of the 3-piece cylinder design it was a continued hope that its cost and procurement time could be reduced.

Before the acceptance of the tangential ports, the next step was to investigate a cast cylinder. After much investigation, the Howard Foundry in Chicago was found to be sympathetic to the idea of trying to cast a completely finned half cylinder of ductile iron. The assembled cylinder is shown in Fig. 3. These same cylinders were later "honey chromed," as shown in Fig. 4.

A uniflow-cooled cylinder was built and tested. In addition, it was a radially ported cylinder for investigating the "squish swirl" piston effect on com-

bustion. While the combination of this "squish swirl" piston and cylinder was nothing to be enthused over, it nevertheless seems to have a potential that is worth while in reducing the cylinder port drop for a compound type of engine. This cylinder and matching piston were run just once because the project was finished before it was again available for test.

As the testing continued, it was evident that the Orion cycle could be much improved if it was possible to redesign the engine and combine, in one cylinder, the following items:

1. Increase the air-fuel ratio in the cylinder.
2. Decrease the port drop across the cylinder.
3. Combine the combustion air and the cooling air compressor, thereby saving high-speed bearings and gears.

Tests of ported cylinders showed that it is possible to get very low pressure drop of the combustion air across the cylinder liner. One cylinder liner, for example, gave an equivalent pressure drop of 2.6 psi. Moving the ports 0.3 in. toward the center of the cylinder gave the equivalent pressure drop of 1.5 psi. Since the pressure drop across the fins is approximately 1 psi, it is possible, by introducing a resistance in the flow through the fins, to have the same pressure drop in the cooling and combustion air circuits. The design of the 6-cyl engine then becomes much simpler, for there is only one compressor (saving one impeller and corresponding gearing) and one air path. It is, therefore, possible in the same engine frame to increase the cylinder diameter by 20%. In addition, the parasitic pressure drop between the cooling air compressor and the cooling fins is eliminated.

Since the change from double-flow to uniflow cooling allowed a larger diameter, a cylinder was designed to reduce the pressure drop to a minimum. The bore diameter was increased from 4.25 to 4.75

Orion Engine Features High Power Density

THE ORION is a gas-generator turbocompound engine of unusually high power-volume ratio. It was developed for tanks and other track vehicles of the Army Ordnance.

It consists of a supercharged, regenerative air-cooled, 2-stroke opposed-piston diesel engine driving two centrifugal compressors. One of these compressors is for combustion air with fine air filtration, while the other is for cylinder cooling with much less filtration.

The cylinder is cooled with air at nearly the supercharge level and at an equivalent temperature because this air later does work on the turbine.

The two airstreams join in a plenum chamber downstream from the engine and the mixture temperature is about 500 F. This hot gas stream then goes to the power turbine, which is mechanically free of the gas generator. The turbine, which is the source of power, provides 600 shp.

The engine forms a rectangular package 35 in. high, 47 in. wide, and 67 in. long. It consists of two rows of three horizontal cylinders each (bore 4¼ in. and stroke 5⅞ × 2 in.), with four 3-throw crankshafts all geared together. On one end are the two centrifugal compressors. These are driven from the gear train that ties all four crankshafts together. On the opposite end of the engine is the power turbine.

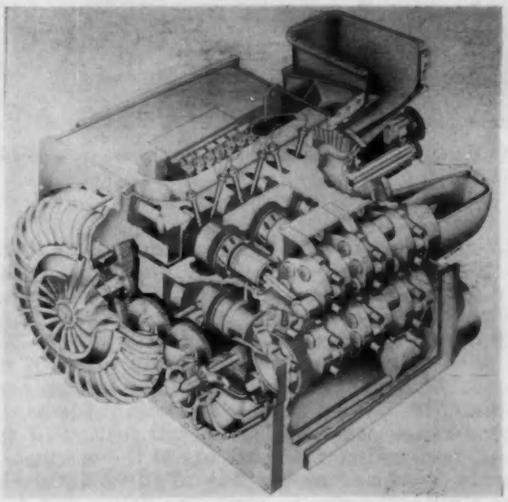
Since the drawing was made, the two fuel nozzles shown extending at an angle to each other from the center of each cylinder have been replaced by a single nozzle. Thus, the six fuel pump discharge fittings have been reduced to three.

The exhaust ports are at the right-hand end of the upper row, but at the left-hand end of the lower row. This cylinder arrangement assures a more even temperature distribution and reduced frame distortion.

Development work on the Orion project started in June, 1950, and was actively being pursued, when orders were received to cancel all outstanding work and complete the project on Dec. 15, 1955.

Actually, the Orion project consisted of a series of engines—three small experimental engines named Alpha, Beta, and Gamma, and two full-sized engines named Rigel I and Rigel II.

The accompanying story tells how some of the more important problems met during the development work were solved.



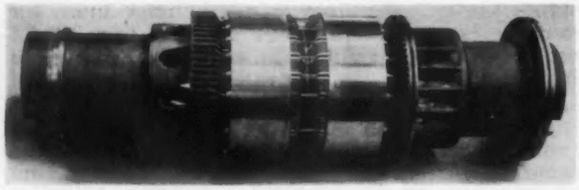


Fig. 3—Assembled cylinder consisting of two cast completely finned half cylinders of ductile iron.

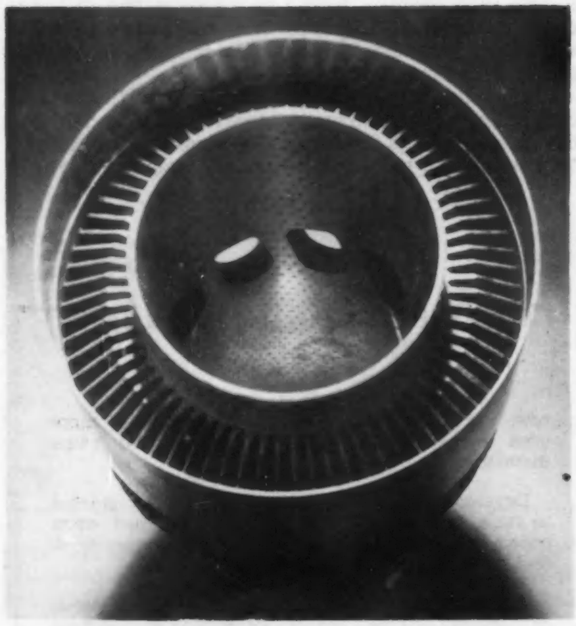


Fig. 4—Cylinder of type shown in Fig. 3 was later "honey chromed," as shown above.

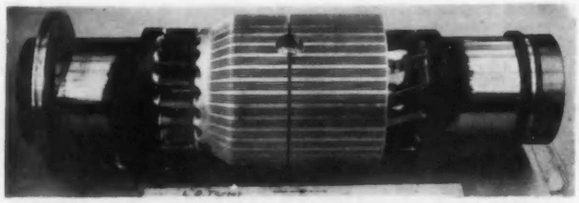


Fig. 5—Uniflow cooling allowed cylinder design with greatly enlarged ports.

in. (that is, 25% increase in the piston area). This permitted the design of much larger ports, as pictured in Fig. 5. Based on previous tests the pressure drop of the combustion air across this cylinder should have been 1.3 psi (at a flow of 0.53 lb-sec^{-1} air) with pear-shaped pistons or 0.8 psi with flat pistons. This cylinder was ready for testing early in March, 1955, when the decision was made to stop all long-range programs. A special feature of this 4.75-in. bore cylinder is that part of the combustion pressure is carried by the fins to the muff around them acting like ribs to carry the firing load from the thin cylinder to the stronger muff. This was done to keep the liner thickness to a minimum and obtain lower cylinder temperatures.

Piston Design

The piston history followed pretty much the same development pattern as the cylinders. To match the original double-swirl cylinder, a flat-top piston was made (see part 1 in Fig. 6). This piston was an all-steel, copper-brazed construction with an Al-Fin muff on the skirt. All of the Orion pistons were oil cooled using the "cocktail shaker" principle. While the fuel consumption with this combustion-chamber shape was poor, the piston ran very well in regard to life and strength.

The next piston design was of the same general style except that the crown was a "Mexican hat" (see part 2 in Fig. 6), and made for concentrating the air closer about the fuel nozzle spray. This crown was used with the single-swirl cylinders and was somewhat better in sfc.

The final piston design, after several modifications, was the "pear-shaped" combustion chamber (see part 3 in Fig. 6). The geometry of this "pear shape" could be formed by a ball end milling cutter feeding in at about 35 deg to the plane of a diameter. Prior to the "pear-shaped" piston a separate aluminum piston skirt design had been completed and was in use. This skirt permitted interchangeability with other crown designs as well as with new wristpin holders.

The "pear shaped" combustion chamber was a marked success from the very beginning. It accomplished several things: first, it permitted the use of one injection nozzle, which had been bench tested and developed concurrent with the pistons and cylinder; second, it tended to reduce the heat rejection through the cylinder wall by covering up the exposed wall; third, it concentrated the air around the fuel spray and made it theoretically feasible to try to increase the equivalent orifice area through the cylinder and added "squish" to the combustion air. By properly designing for "squish-swirl," it was felt that it would be theoretically feasible to increase the equivalent orifice area through the cylinder, by using radial ports, rather than the tangential ports.

The next revision was a modification converting the "pear" to a "spherical" cavity that could be turned on a lathe (see part 4 of Fig. 6). These piston crowns were used in cylinders having a very strong tangential swirl. All of these crowns were machined from low carbon steel and consequently were not corrosion or high-temperature resistant. With engine performance improving, running time was getting longer, so that burning of the piston's "pear" and "sphere" edges at the nozzle openings was appearing, mostly on the exhaust piston. Rather than make stainless-steel crowns, two ways were tried to reduce the burning; one was to chrome plate the crown above the ring belt and the other was to chromallize the surface above the top piston ring. While chrome plating was easy and cheap to apply and helped to demonstrate a cure, it would not stand up under the high-temperature gradients. The bond strength would fail and allow the plating to peel off. The chromallized process is a metallurgical addition of chrome to the skin for a depth of about 0.0015 in. This proved to be a cure for the burning, as demonstrated by over 100 hr of operation. In-

cidentally, the carbon could be wiped off easily, leaving a smooth, brownish appearance to the crown.

One area of burning started at the channel for the nozzle spray. It was reasoned that, since the top edge of the crown opened the exhaust ports for blowdown, the channel for the nozzle spray of the "pear," being nearly as wide as the port land, would pre-open the port, allowing a much longer time for the hot gas to blow across the channel edge. It would at least contribute to the burning rather than the opposite effect. In order to reduce this pre-opening effect, a set of pistons was made without a channel and tested. The results were poor but by progressively hand filing a channel in the crown it was possible to demonstrate that only about one-half the opening originally provided was required (see part 5 in Fig. 6).

It was recognized that the reduction of scavenge port drop might be accomplished if it was possible to develop a "mechanical squish swirl" piston that would create the necessary turbulence as the pistons approached inner volume dead center. Accordingly, two basic crown designs were constructed. One was a spherical cavity crown with the swirl lips oriented to produce a swirl about the axis of the fuel nozzle spray. This piston is shown in Fig. 7. The second piston crown was a "cylindrical" cavity with the swirl lips also producing a swirl velocity about the axis of the nozzle (two nozzles could be used with this crown). Both of these piston crowns and swirl lips were of the same orientation so that two of the same part number made a complete combustion cavity. The third modification was similar to the first spherical cavity crown except that the swirl lips were turned 90 deg to enable the swirl to cross the fuel spray.

Of these pistons, only the first spherical cavity was ever used in an engine. The swirl lips were only about half the height shown, and while there was an improvement in the sfc when used in a tangentially ported cylinder, it was marginal. The lips were doubled in height by welding, but the project ended before they could be retested in the single-cylinder engines.

Fuel Injection

During the initial developmental testing of the Orion, it became evident that a broad investigation of fuel-injection systems was warranted to attempt to establish high engine performance with a single fuel injection nozzle. This discussion constitutes a memorandum of the design of one of the most satisfactory systems derived—the accumulator nozzle system.

The objectives of this design study were:

1. To reduce the duration of fuel injection into the cylinder for a given quantity of fuel.
2. To isolate from the injection process, the influence of the volume of tube between pump and nozzle.
3. To increase the fuel pressure, on which control of injection is dependent, without overloading the pump drive mechanism.
4. To increase initial fuel-flow rate so that a greater per cent of fuel might be burned at a constant combustion-chamber volume.
5. Eliminate pump delivery valves.
6. Use an eccentric cam.
7. Extend the pumping over a larger camshaft angle.
8. Eliminate the need for a leak-off line.
9. Use somewhat smaller injection tubes—since the charging rate is much reduced.

The principle of the accumulator system is that

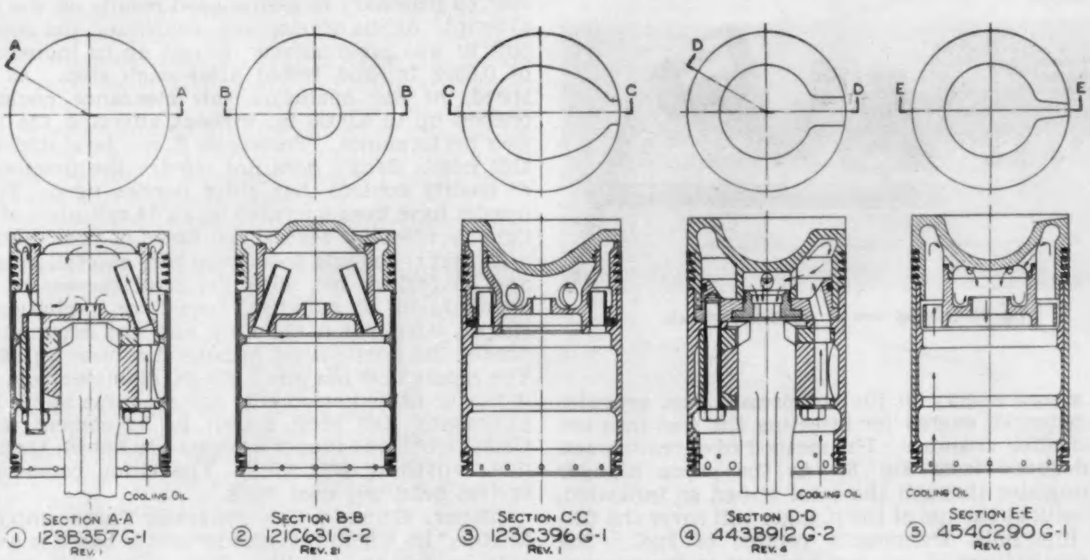


Fig. 6—Some of the many designs of piston tried during development stage.

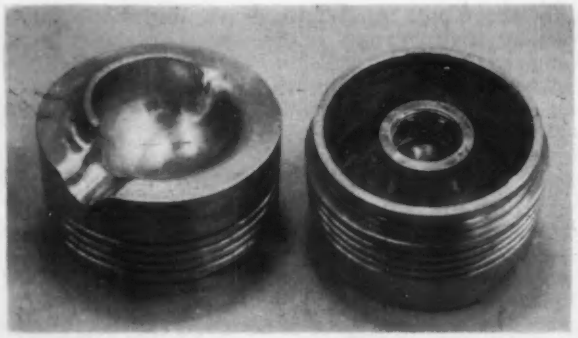


Fig. 7—Piston having spherical cavity crown with swirl lips oriented to produce swirl about axis of fuel nozzle spray.

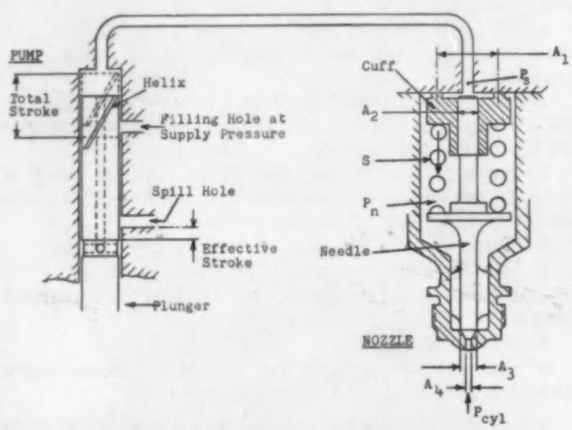


Fig. 8—Method of operation of accumulator nozzle system.

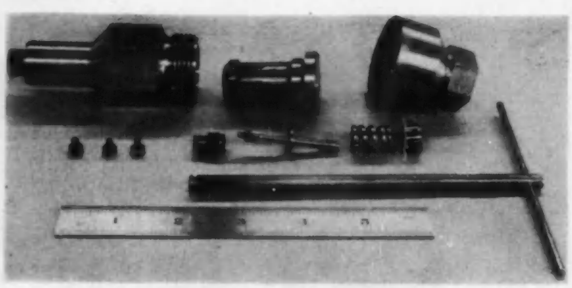


Fig. 9—Exploded view of accumulator nozzle.

the stored energy in the compressed fuel provides the potential energy for injecting the fuel into the combustion chamber. The method of operation can be deduced from Fig. 8. As the pump plunger reciprocates through the total stroke as indicated, the helix at the top of the plunger will cover the filling line hole, trapping a volume of fuel. The trapped volume of fuel is a function of the angular position of the helix. As the plunger continues to lift, the fuel is pumped through the injection line into the nozzle body. Pumping continues until the spill edge at the bottom of the plunger matches the spill hole as shown, at which time the pressure is relieved in the plunger-barrel volume and the injection line.

Initially, spring *S* holds the needle on its seat at the nozzle tip, and the cuff on its seat at the nozzle top. When pumping starts, the cuff is lifted from its seat and fuel flows into the nozzle body; and in accordance with the compressibility, the pressure of the fuel within the nozzle is increased. When fuel delivery is interrupted by spilling of the injection line, the cuff returns to its seat, retaining the pressure within the nozzle. Since the fuel pressure (P_n) times the area (A_2 minus A_3) is greater than the spring force (S), the needle is thereby forced upward, opening the spray orifice for the injection of the fuel.

Flow continues until the pressure within the nozzle body is less than that required to overcome the spring force, at which time the needle closes. The cycle is then complete and ready to be repeated.

While the quantity per injection is a function of the plunger angular position as stated above, the beginning of injection is controlled by the position of the "spill edge" on the plunger. An exploded view of the accumulator nozzle is shown in Fig. 9.

The objectives listed previously were real and each was obtained. There is only one critical dimension that has to be closely controlled—the lift of the needle. The peak injection pressure used was about 14,000 psi, but pressures well over 20,000 psi have been tested. When the spill edge of the plunger dumps the line, a "sledge hammer" blow accelerates the needle opening to the extent that, if the lift is too large, the resulting velocity of the needle will hammer it to pieces when it strikes the stop. To prevent this, the lift was limited to 0.009 in. on the subject design.

The fit between the upper needle diameter and the cuff were at first of very high quality, approaching that of the Bosch-type needle fit. This was considered necessary to assure good results on the first attempt. As the development continued, the needle-cuff fit was progressively opened up in increments of 0.0002 in. and tested after each step. At the speeds of our operation this clearance could be opened up to 0.0006 in. without affecting the nozzle's performance. Therefore, it can be stated that this nozzle design does not require the preciseness of quality control that other nozzles need. These nozzles have been operated on all 14 cylinders of the Orion project for several hundreds of nozzle hours.

At first the nozzle holes were very carefully placed and controlled, but with the final success of the combination of cylinder, "pear" or "spherically" shaped combustion chamber and the accumulator nozzle, the nozzle holes became fire hoses in effect. The nozzle now has one 0.043-in. diameter hole and it can be drilled on almost any machine tool. This philosophy has been shown to be correct many times; when the proper answers are known then almost anything will work. The Orion combustion system definitely does work.

(Paper, "Orion—a Gas-Generator Turbocompound Engine," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Boeing 502-10C Gas Turbine

... has more power, less fuel consumption than predecessors.

Based on paper by **Wallace E. Skidmore,** Boeing Airplane Co.

LATEST in the family of Boeing small gas turbines is the model 502-10C. It delivers 240 hp and its fuel consumption is 1.0 lb per hp-hr. Weight of the complete engine is 320 lb. Boeing considers it a contender for powering small aircraft, boats, trucks, buses, and compressors.

Improvement in performance over previous models was accomplished by increasing pressure ratio and increasing the diameters of the turbine wheels. The present rating (240 hp corrected to 60 F standard day) represents 30% increase in power for the same fuel flow and rotor speeds as the earlier models. Performance characteristics are shown in Fig. 1, while Fig. 2 shows a breakdown of the engine to illustrate component accessibility.

The new 4.25/1 pressure ratio centrifugal compressor operates at 77% efficiency. The cast-aluminum collector and diffuser sections were designed for minimum machining. Impeller and inducer are machined from 14 ST forgings and spline-connected to the rotor shaft. Precision castings or forgings eliminate machining of vanes and show promise for production use. Breakdown of separate inducer and impeller was found necessary to get the higher pressure ratio and increased efficiency.

All burner details can be used interchangeably on left- or right-hand assemblies. A single clamp fastens the burner shell to the compressor adapter elbow, and the entire assembly is clamped to the compressor by means of a hollow strut which also admits fuel to the nozzles. Air seals for the burner shell connection are provided by O-rings.

The turbine rotor is supported by three floating-type bearings, which allow detail parts to be component balanced and used interchangeably without assembly balance. This is possible because of the radial freedom of the rotor to spin about its mass center rather than its geometric center. Elimination of high-frequency rotor unbalance has put an end to sheet metal parts failures of burners, crossfire tubes, brackets and heat shields.

Turbine wheels are made by welding precision-cast blades to the hub. The shaft of the first-stage rotor is welded to the hub, and the second-stage shaft and wheel are assembled by shrinking the parts together. By making the hub and shaft from an integral forging it is possible to eliminate the shaft joints. Both fir-tree and cast wheels have been studied and tested extensively and found to have merit as low-cost items. Automatic welding also is a cost-saving item. Experience leads us to believe the welded construction has a slight advantage in strength over fir-tree and cast construction.

The lube and filter have been included in the accessory section. All lines distributing and scaveng-

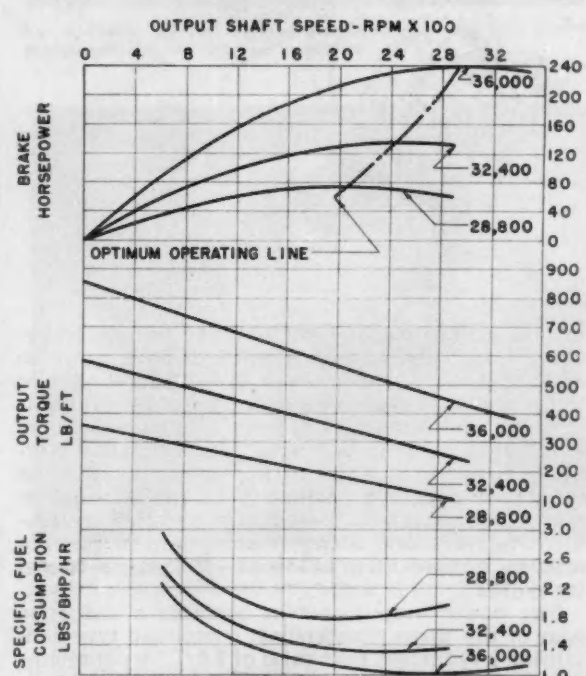


Fig. 1—Typical performance characteristics of Boeing 502-10C gas turbine (corrected to 60 F standard day).

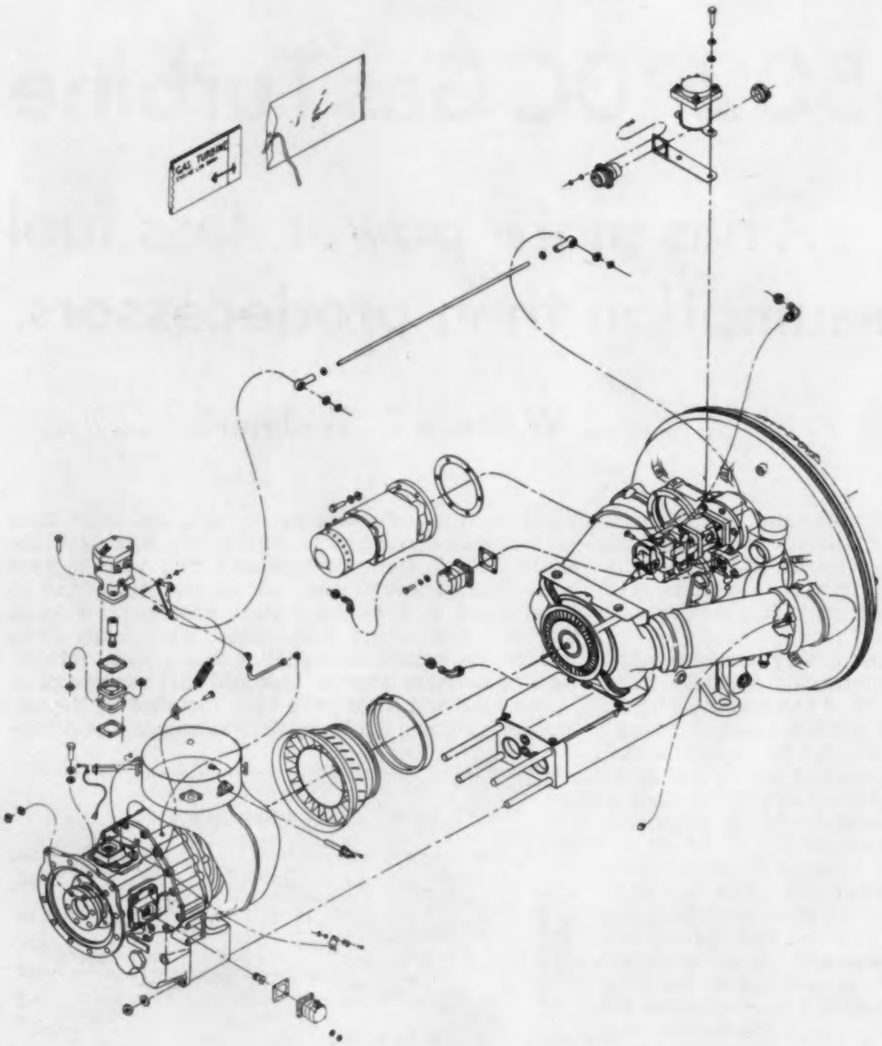


Fig. 2—Component accessibility of the 502-10C, newest of Boeing's small gas turbines, is shown by this engine breakdown.

ing oil throughout the engine have been incorporated internally, adding greatly to both function and appearance of the engine. By placing the cooler in the scavenge pressure line, the possibility of high-pressure cooler failure has been eliminated. Rated lube pump capacity is 5 gpm. Lube pressure normally varies from 10 psi at idle speeds to 30 psi at normal rated speed. Capacity of the oil sump is 6 qt. Lubricating oil most commonly used for ambient temperatures above freezing is SAE 10. For ambient temperatures as low as – 65 F, a low-viscosity synthetic oil is used.

The power output section contains a reduction gear of the three countershaft compound type containing a reduction gear ratio of 8.9/1. By changing ratios of the secondary mesh only, it is possible to provide output speeds from 2000 to 5000 rpm. Pitch line velocity of the primary or high-speed mesh is 10,000 fpm. AGMA methods of determining contact stresses have been used in the gear design. Long and short addendum system to balance beam strength between pinion and gear has been used to prevent scoring.

Provisions have been made for three accessory drive assemblies on the reduction gear. These are installed when required. Exhaust collectors have been provided for single or double outlet stacks to satisfy the many installation requirements. A substantial cost saving was made by providing a one-piece collector assembly and eliminating an axial split joint with bolted flange connections. Four thermocouples, connected in parallel, are included in the exhaust stacks to provide for accurate measurement of the average exhaust gas temperature.

The speed control unit (developed by the Woodward Governor Co.) is shown in Fig. 3. All components, including the fuel pump, with integral accessory drive gear, governor acceleration limiter and

fuel shutoff valve, are combined in one unit with internal fuel passages. There are no restrictions on the type of fuel used. A gear pump supplies fuel up to a maximum pressure of 750 psi. The flyball governor meters fuel to the nozzles in sufficient quantity to maintain the desired throttle settings. Acceleration speed is controlled by a limiter valve which regulates the maximum rate of fuel flow at any instant in proportion to the compressor air discharge pressure. Adjustments are provided for regulating starting fuel flow, idle speed, maximum speed, and acceleration rate.

When output speed is required, a second governor of the speed-sensing servo type (containing a mechanical link to the gas producer throttle arm) is installed on a reduction gear accessory drive. Control is then accomplished by (1) operating the output speed governor throttle arm to maintain constant output speeds or (2) operating the gas producer throttle arm, in which case the output speed governor acts as an override only to limit output shaft top speed.

The engine is started by an automatic control developed primarily to prevent operator errors and to avoid engine failures from a malfunctioning ignition system during the starting cycle.

The system is simple and experience proves it to be highly reliable. Low battery, a malfunctioning starter or ignition system, one burner starts, or any other troubles which might cause delayed starts are prevented from damaging the engine. Automatic starting is standard on production engines.

Additional safety devices for engine shutdown, such as a low oil pressure cutout, high oil temperature cutout, high exhaust temperature cutout, and overspeed protection, have been found to complicate installations and cause endless trouble. Reliable, trouble-free components capable of withstanding abnormal operating conditions are necessary if safety devices are to be eliminated. And this is the philosophy behind the design of the engine.

Efforts to reduce manufacturing costs are beginning to show results. Studies to determine the selling price indicate the engine to be competitive with reciprocating engines if it is produced in like quantities. Manufacture at the rate of 50 engines a month reduces the unit cost to $7500.

The 502 series engines have proved their service life to be superior to that of many reciprocating engines, and while the 502-10C engine is relatively new and experience is limited, the design incorporates all the features of the earlier models.

The gas turbine can be used to great advantage where full-throttle operation is required. Fig 4 shows the engine prepared for turboprop installation. It is mounted from the compressor end with double outlet exhaust collectors. Boats provide another ideal application. A propulsion package, coupled to a reverse gear, was recently delivered to the Creole Petroleum Co. Two such packages, each weighing about 550 lb, have been installed in a 40-ft supervisor's speed launch for operation on Lake Maracaibo, South America. The package weight is approximately one-fifth that of a diesel.

The small gas turbine is ideal for trucks and buses. As an example of compressor application, Fig. 5, shows a 502-11B air compressor using the 502-10C gas producer driving a single-stage compressor.

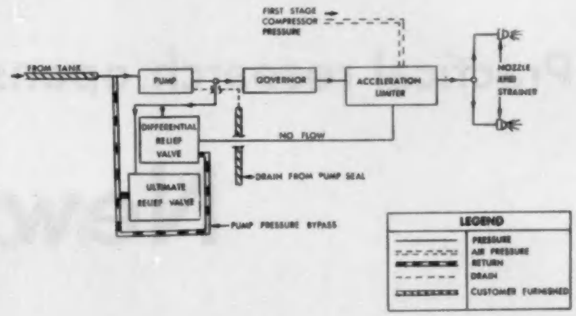


Fig. 3—Fuel system diagram, indicating components and path of fuel flow incorporated in governor control unit. All components, including fuel pump, with integral accessory drive gear, governor acceleration limiter and fuel shutoff valve, are combined in one unit with internal fuel passages. Type of fuel used with this system is unrestricted.

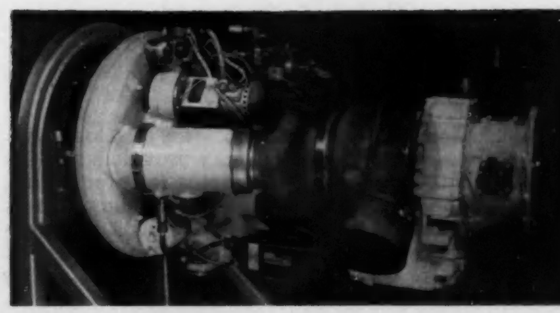


Fig. 4—Boeing 502-10C mounted from compressor end, with inverted exhaust collector, for turboprop installation.

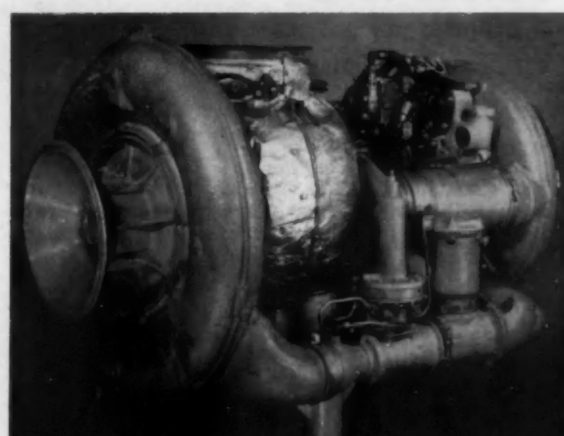


Fig. 5—Boeing 502-11B air compressor engine comprises 502-10C gas producer driving a single-stage compressor.

(Paper, "Evolution of a Gas Turbine," on which this abridgment is based, is available in full, in multilith form from SAE Special Publications, 485 Lexington Avenue, New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Practical research opens . . .

New Possibilities

EXCITING new production processes and techniques are being developed through "practical" research by the Process Development Section of GM. Objectives of this program are:

1. Reducing costs.
2. Improving labor utilization.
3. Improving product quality.

This article discusses some of the developments of the research program and may provide some indication as to what the future holds for production.

One of the major ways to reduce product cost is through better material utilization. And probably one of the most interesting fields for the saving of material is in the cold extrusion of metal. The major advantages of this process include:

1. Reduced material usage.
2. Lower-cost material.
3. Improved physical properties.
4. Reduced machining.
5. Improved finishes.
6. Closer tolerances.

Work in this field at the GM Technical Center has been limited to relatively small parts, as the largest press included in the facilities has a capacity of 600 tons. Even so, experience has proven the great potential of the process. Fig. 1 shows some typical parts made by cold extrusion.

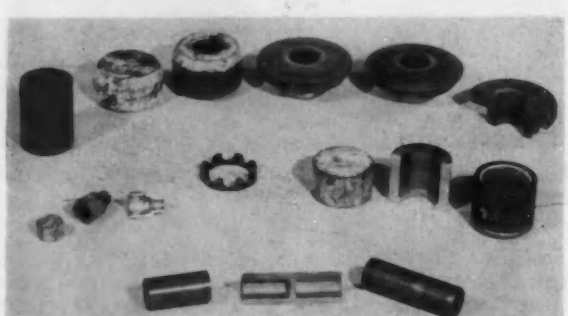


Fig. 1—Typical parts made by the cold extrusion process.

The development of new metal-coating materials and processes also promises future material-savings possibilities. In many cases where high-cost materials are required because of surface characteristics only, new coating processes have permitted the substitution of low-cost base materials. And, corrosion resistance, wear resistance, heat resistance, and other properties can often be more adequately provided than through the use of alloys and at less cost.

The jet-engine turbine wheel shown in Fig. 2 formerly was made of stainless steel which was extremely difficult to machine. Now the use of electroless nickel plating, which permits a uniform deposit over all surfaces, has permitted changing to a low carbon steel.

Ceramics, carbides, molybdenum, and many other coatings now available—and others being perfected—will prompt a host of new applications in this field.

The direct conversion of steel machining chips into parts is another process which has been improved to the point where it has great potential for future material savings. Techniques have been developed which make this a relatively simple process and the continued rise of steel prices make the economics of the process even more favorable. The physical properties of parts made from steel chips closely approach those made from mill-processed steel.

Another recent development which excites the imagination because of its potential industrial application is the use of metal adhesives. While they may not completely replace conventional joining processes such as brazing, soldering, and welding, they should find wide application. Use of metal adhesives in the assembly of aluminum die castings, in the application of metal body trim, and in many other manufacturing tasks will challenge the ingenuity of engineers for some time to come.

Improving Labor Utilization

Probably the greatest immediate opportunity to improve labor utilization lies in using modern methods-engineering techniques and procedures to insure that even the smallest increments of expended effort are productive. Capitalizing on this oppor-

Based on paper by **Glen R. Fitzgerald,** General Motors Corp.

for Production

tunity requires that as much careful study be given to the manual portion of a job as is usually given to the mechanical portion.

At GM, the largest single group in the direct labor force is employed on assembly work. This is an area that has been traditionally manual and offers great potential for continual improvement through the application of methods engineering. Aside from this point, however, much is being accomplished in the development of mechanical assembly equipment. One GM division alone has over 100 semiautomatic assembly machines in operation at the present time.

Probably the greatest limiting factor to the use of such equipment is economic. Assembly equipment is quite expensive because presently there are only a few standard equipment answers to assembly problems. Most assembly equipment must be designed and developed to suit a specific situation. However, as the demand for assembly equipment increases, we can look forward to the development of "off-the-shelf" items which can be placed together readily and thereby perform the assembly function. This should materially reduce the cost of such equipment and thus provide a much wider application for its use.

AC Spark Plug Division uses an assembly machine to assemble the various components of a spark plug. The only manual operation involved with this equipment is the loading of the insulator assembly. Fragility of this vital part dictates the use of manual-assembly means.

Oldsmobile's Head-Assembly Machine is 137 ft long and assembles the 73 parts required on an Oldsmobile cylinder head. It operates at a rate of 400 complete assemblies per hour. Operating at this rate the machine assembles a total of 29,600 separate pieces each hour.

Another area of great potential improvement is that of material handling. While the improvement possibilities in this area may not seem as obvious as in some other, nevertheless, much progress is being made. The integration of equipment with simple material-handling devices to provide continuous flow processing is being widely adopted where product uniformity will permit. The use of new power-and-free type conveyors will continue to find greater application if their cost can be reduced. Further, the use of electronic computers in the control of production logistics offers tremendous opportunity for improvement in material handling.

Improving Product Quality

The objective of product-quality improvement is one of ever increasing importance to manufacturers and it is in this field that we see many applications of new discoveries of science.

Development in the field of electronics have provided us with many new inspection tools that are contributing importantly to improved quality. The use of automatic feedback control with continuous automatic gaging systems, for example, have considerably improved the tolerances possible with modern grinding machines. Gaging circuits may now be developed which will do the same for machines using single point tools and, in addition to policing of size limits, will also indicate tool trends and, in many cases, anticipate cutting tool failure prior to the making of a faulty piece.

Other applications of electronics and related techniques are equally exciting. The measurement of vibration, or noise, in such items as ball bearings,

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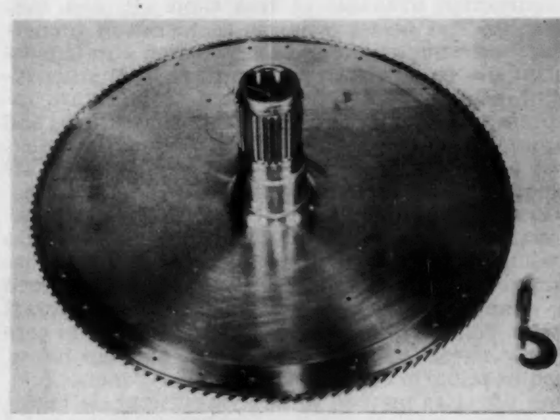


Fig. 2—This jet-engine turbine wheel formerly was made of stainless steel which was very difficult to machine. Now the use of electroless nickel plating permits making this wheel of low-carbon steel.

Brazing
Adhesive Bonding
Resistance Welding

3 Joining Methods for High-Temperature

HIGH-temperature sandwich construction finds increasing application in today's aircraft due to its light weight and good strength-to-weight ratio. Methods commonly used for attaching the airplane skin to the honeycomb core include:

1. Brazing.
2. Adhesive Bonding.
3. Resistance Welding.

As aircraft speeds increase, so do temperature, weight, and strength problems increase. At Mach 2 and 80,000 ft, temperatures of approximately 250 F are encountered, while at Mach 3 they have nearly tripled to 650 F.

Titanium and steel provide sufficient strength at these elevated temperatures and thus have found increasing acceptance. But these materials are heavy. Sandwich construction, however, permits using extremely light gages and provides the continuous support needed to assure stability.

Brazing

Stainless-steel honeycomb sandwich is being brazed because it appears to be the best means of construction available at this time. Brazed construction has better strength-temperature properties than adhesive bonded construction and is more adaptable than welded construction to the honeycomb configuration. Operational temperature requirements for various components of airframes and aircraft engines already exceed the limits of adhesive materials, and temperature requirements are expected to continue increasing.

Brazing not only meets these increased operational temperature requirements, but also makes possible joints of high strengths between widely dissimilar metal thicknesses, such as are encountered in adapting honeycomb construction to aircraft parts. Joint types include: T joints, such as in core to face sheets and core to flanges; and lap joints, such as occur in edge members and stiffeners.

An effective method of applying the braze material to the joint areas is to place the braze material in sheet form between surfaces to be joined. This might not appear to be most efficient from the standpoint of minimum use of braze in the honeycomb-attachment areas, however, the capillary effect of the braze to the side-wall of the honeycomb when proper temperature, process control, and braze alloy are utilized results in a minimum braze weight versus core to face sheet bond strength.

Selection of the brazing alloy for honeycomb-steel-sandwich construction requires careful consideration of the following factors:

- The filler metal should be stable throughout the required operational temperature range. That is, it must retain adequate mechanical properties and not oxidize or corrode. It is preferable that the melting and brazing temperature of the filler metal be above or at least as high as the heat-treating temperature required for hardening the parent metal.
- The corrosion and oxidation resistance of the filler alloy should be adequate to meet the environmental life required for the completed part. Corrosion of the filler metal can result in complete failure of the sandwich at very low loads.
- The sandwich parts should be protected during brazing. Various fluxes are used. These usually contain materials such as borax, boron trifluoride, sodium borofluoride, sodium fluoride, or lithium fluoride. In recent years, fluxes have been replaced to some extent by furnace atmosphere. However, brazing fluxes, at times, are used in conjunction with furnace atmospheres to improve the flow of filler metal.

Convair's supersonic B-58 is the first production aircraft to utilize brazed-stainless-steel sandwich as primary structure. The basic material making up the sandwich (17-7 precipitation-hardening stainless steel) retains good mechanical properties at elevated temperatures. When properly incorporated in a sandwich configuration of optimum design, it has a comparatively high strength-to-weight ratio in the temperature range of 600–900 F.

The honeycomb core provides complete stabilization of thin facings, and effectively eliminates the heat sinks and thermal buckling normally associated with high operating temperatures. This results in an extremely smooth aerodynamic surface.

A. A. Lanzara, General Dynamics Corp.

Sandwich Construction

In addition, tests have shown that under extreme conditions of heat, vibration, and sound, this type of construction has excellent fatigue characteristics.

The brazing alloy used on the B-58 is 85% silver and 15% manganese. Tests have shown this alloy to be adequate up to approximately 900 F for short time exposures. Lap shear tests have shown that this alloy may be worked to 19,600 psi at room temperature and to 12,000 psi for short time exposure at 900 F. To demonstrate the elevated temperature properties of this alloy, two 12 × 24 in. sandwich panels were exposed to a temperature of 900 F. Temperature was maintained at this level while each panel was loaded from 5000–50,000 psi in axial compression 100 times. After the one-hundredth loading, with the temperature still at 900 F, the panels were loaded to failure. The failing stress in each case exceeded 100,000 psi. A third panel was flash heated to 1100 F at a rate of approximately 30 F per sec. This panel warped visibly during heating, then straightened as it cooled. It was then tested in axial compression, and failed above 150,000 psi, which indicated that the brazed joints had been unaffected by the elevated temperature.

Adhesive Bonding

Adhesive bonding is an interim step in the transition to the ultimate in metal-to-metal joining for high-temperature sandwich construction. And, in consideration of the maximum requirements imposed on sandwich structures in high-speed aircraft, as envisioned in the clearly foreseeable future, it is limited.

But adhesive bonding appears to be the first logical step in the transition from low- to high-temperature-performance sandwich construction. Experience proves it an economical method of construction. Reliability stands high in the list of attributes of this manufacturing process, for there is no known record of a service failure of an adhesive-bonded structure. In addition, established and proved design concepts will not require a major overhaul to adapt them to the production of aircraft for high-temperature performance.

Effort and experience in the development of bonded structures for high-temperature performance has centered in the use of the epoxide-phenolic-type adhesive. This type of adhesive, in film and liquid form, however, is subject to progressive curing upon exposure to normal ambient temperatures and, therefore, requires refrigeration to obtain the maximum shelf life and to retain the properties which are necessary for subsequent application in the bonding process.

Time is a most important factor, and this presents a scheduling problem to insure that the established limitations on exposure of the adhesive to room temperature prior to bonding are complied with. This problem can be minimized by providing temperature and humidity control in the layup area prior to bonding.

As with bonding aluminum structures, tolerances of details must be held to the same close limitations for steel to insure proper mating of the bonded assembly, so that dimensional as well as physical quality is embodied in the finished product.

Experience has shown that the recognized stand-

SERVING . . .

. . . on the panel which developed the information in this article were:

R. A. Fuhrer, panel leader
General Dynamics Corp.

O. T. Pfefferkorn, panel co-leader
North American Aviation, Inc.

A. A. Lanzara, panel secretary
General Dynamics Corp.

K. W. Goebel
Rohr Aircraft Corp.

L. E. Laux
Glenn L. Martin Co.

E. F. Mellinger
Ryan Aeronautical Co.

ard production types of bonding equipment and tools are generally adaptable for producing sandwich structures for high-temperature applications. However, specific consideration must be given to the inherent characteristics of the materials incorporated in the bonded structure and in the bonding process requirements imposed by the epoxide-phenolic-type adhesive.

The coefficient of expansion of steel components may well dictate the more extensive use of steel-bonding fixtures, although through proper design considerations, aluminum tools will perform satisfactorily in many cases.

The curing of the epoxide phenolic adhesive requires a precure to facilitate resin advancement and general adhesive wetting and flow. It is currently felt that a precure at 200–220 F at 1% of the final pressure for 15–25 min, followed by a final cure at 330–350 F at 40–100 psi for ½ hr, produces structures with the most satisfactory physical properties. Cool-down to approximately 200 F under full pressure is currently considered desirable, although further evaluation may justify elimination of this step on certain types of assemblies.

Resistance Welding

The advantages claimed for resistance welding of sandwich structures include:

1. Relatively low cost facilities required.
2. Conventional-type tools and fixturing can be used.
3. Pre-heat-treated details can be used.
4. Current quality techniques can be applied to this new field.

The development of new configurations of minimum-weight structures using the resistance welding approach is now under way. It is expected that these new configurations will show that the resistance-welding method affords maximum advantages for joining titanium and steel structures at a production cost which approximates current manufacturing costs for aluminum structures.

(The report on which this article is based is available in full, together with reports of 13 other production panels. This publication, SP-317, is available from the SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $2 to to members; $4 to nonmembers.)

New Possibilites for Production . . . (Continued from Page 61)

gear trains, and electric motors has long been used as an indicator of quality. However, when done by humans, precise and repeatable standards cannot be established. Electronic means of noise testing in addition to making possible the setting of accurate standards permit their measurement in total or in individual frequency ranges, some of which may be outside of the range of the human ear.

The photocell and phototransistor have also relieved the human eye of the fatiguing task of inspecting ground or polished surfaces for tiny flaws. By precisely measuring the change in light reflection between a fault and the desired surface, blemishes barely perceptible to the human eye can be detected with unbelievable rapidity.

Another significant item is the use of ultrasonics, magnetic techniques, and radioactivity to inspect for characteristics that heretofore have been determinable only by destructive means. Of these techniques, the use of ultrasonics is probably the one which promises the greatest future development. We are all familiar with its use for flaw detection in steel blocks that defy the largest available x-ray equipment. You may not be aware though of the extent to which ultrasonics can be used to check weld quality. Such applications range from inspecting welded oil filter studs at 750 pieces per hour, to the inspection of brazed steel aircraft propeller blades. Inspection of these blades requires the scanning unit to travel a total of 600 ft, to check one blade.

Another electronics application which will be of increasing interest to production engineers is that of static machine controls. One of the most serious problems with modern automatic equipment is the trouble shooting and maintenance of electrical control circuits. Limit switches and relays cannot be expected to last indefinitely nor can the faulty ones always be quickly found and easily replaced. Recently developed static-control systems which eliminate a large percentage of the moving parts of an electrical-control system will contribute effectively to improvement in this area. In a recent installation of several automatic machines, one was equipped with a static circuit for comparison with the others using conventional controls. The static or mag-amp circuit developed only two operational failures in 9,000,000 cycles, while it became necessary to replace relays in the other after 3,000,000 cycles. This type of control is now more expensive but costs should be reduced as volume increases and experience is gained by its manufacturers.

Another item which undoubtedly will receive attention in the future from production engineers in the auto industry is tooling costs. The expense and time involved to re-tool, even for minor styling changes, has increased tremendously. Thus, to continue to satisfy the demands of the buying public, this area must be thoroughly studied by production engineers. It is too early to predict how this will be accomplished but recent developments in "cookie cutter" dies for sheet metal blanking and piercing and plastic dies for drawing and forming indicate they are worthy of consideration. Dies made by these techniques generally are one-tenth the cost of conventional dies. Of course, their life is much shorter but improved materials and knowledge of their use will prove them to be adequate for many applications.

(Paper, "Process Improvements Being Developed Through Manufacturing Research," on which this abridgement is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers.)

Three New Tractor Hitches . . .

. . . provide easier hookup to implements, better traction, and interchangeability. All can handle larger implements and all use hydraulic control systems.

● Designing the Minneapolis-Moline Three-Point Hitch

The Minneapolis-Moline 445 tractor is equipped with a three-point hitch that is automatically draft sensitive and capable of lifting and controlling implements of a size compatible with the power available in the tractor. During its design special consideration was given to: the size of the implements; the method of draft-sensitive hydraulic control; the ease of implement hookup; and the use of as many common parts as possible.

From a study of the stability line of the tractor against rearward overturning and from considerations of rear-tire loadings, hydraulic lift capacity, and rear-axle strength, a limit weight for implements was set as shown in the top curve of Fig. 1.

Here the weight of the implement is plotted against the distance its c.g. is aft of the hitching pins. A similar curve for a smaller tractor is shown at the bottom of Fig. 1.

Since all the tools developed for this smaller tractor had been made to category 1 dimensions, the greater side stability afforded by wider lower points was needed. And because the weights allowable were much larger than before, it was decided to adopt the basic category 2 hitch-point dimensions for use on the 445 Tractor and to limit the tool weights to the upper curve shown in Fig. 1.

Thus a hitch was designed with 1⅛-in. bottom pull link pins laterally spaced at about 34 in. at the implement, and with a basic mast height of 18 in. and using a 1-in. pin. This mast height has been varied on the Universal model by using a mast extension which permits a common hydraulic system and common links to be used on both the Universal and Utility models of the 445 tractor.

This design was satisfactory for the larger sizes of attached implements intended for the 445 tractor but there were also a number of specialty tools of the category 1 size which it seemed desirable to attach to the tractor. In general, the category 1 tools are not too sensitive to draft lines and by compromising the lateral dimensions at the forward end of the lower pull links it was possible to get satisfactory stability with both sizes of tools at a common forward location.

To mount the category 1 implements which have ⅞-in. lower-hitch pins spaced laterally at about 28 in. and a ¾-in. upper pin on an 18-in. mast, bushings for the implement end of the upper link are provided in an auxiliary package supplied with the three-point hitch.

● Hydraulic Lift and Draft Control System

In designing the hydraulic lift and draft control system, it was decided that the draft signal for the automatic actuation should be measured from the

THIS ARTICLE on tractor hitches is based on the following papers:

"Design Considerations of Three-Point Hitch for the Minneapolis-Moline 445 Tractor"
Thomas Evans
Minneapolis-Moline Co.

"The John Deere Universal Three-Point Hitch with Load and Depth Control and Associated Hydraulic Controls"
John H. Edman
Deere Mfg. Co.

"Traction Boosting with Heavy Implements Having Transport Wheels"
Roy W. Johansen
Allis-Chalmers Mfg. Co.

Each of the above papers is available in full, in multilith form, from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ each to members; 60¢ each to nonmembers.

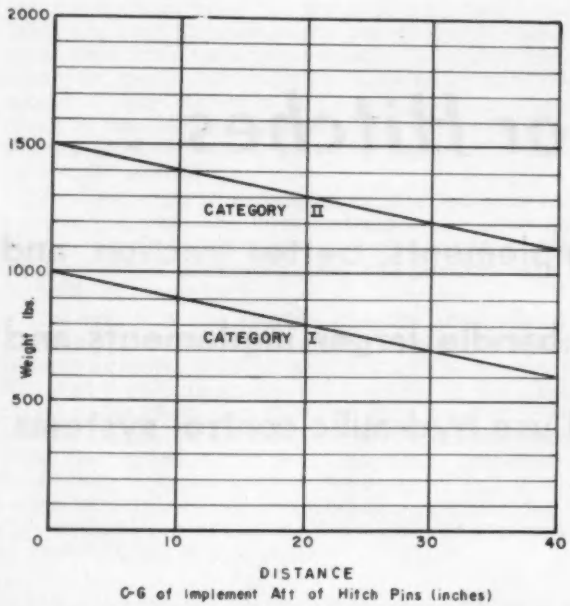


Fig. 1—Limit weights for tractor implements vary with distance of implement c.g. from hitch pins.

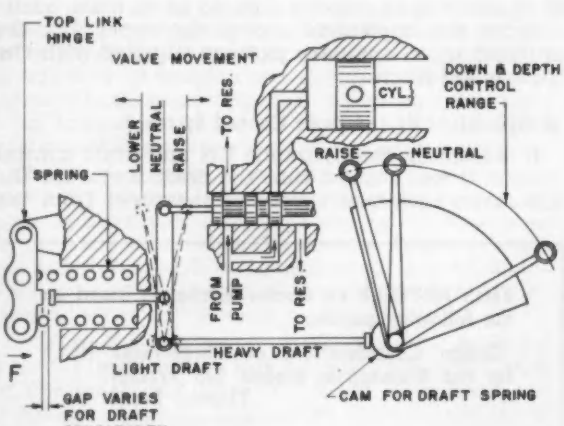


Fig. 2—In Minneapolis-Moline's hydraulic lift and draft control system, draft signal for automatic actuation is measured from compression in upper link. This load actuates compression spring in hydraulic assembly, which in turn actuates hydraulic valve, lifting implement.

compression in the upper link (Fig. 2). The compression load (F) in the link, working against the spring overcomes the spring and pushes on the control shaft moving the bell-crank and moving the hydraulic valve so that oil pressure from the pump flows to the main lift cylinder, raising the implement.

When the draft drops to a point where the compression in the upper link is below the amount required to compress the spring far enough to actuate the valve in the raising direction, the valve is spring returned to the lower position and the implement returns to its deeper position. The initial load at which this happens is determined by varying the gap between the hinge and the actuating shaft with the main control lever and through the cam on this lever. To achieve greater sensitivity with a given total cam movement, two range holes are provided in the hinge; the bottom for implements of comparatively light upper link compressions and the upper for implements with comparatively high compressions.

The hydraulic lift unit was designed as a package and can be supplied as optional equipment. The top of the differential case is milled off and tapped on all tractors. A cover plate is installed when the hydraulic lift is not desired. When desired, the lift package is capscrewed in place. Ports to the pump are contained in the differential case and communicate through seals with the lift package.

One of the major design considerations was that of hooking-up to the heavy implements that the tractor can lift and handle. Since an 1100-lb harrow is rather immovable to one "manpower," and a tractor operator that can spot within fractions of an inch is not always available, the lower pull links were designed so that the ends can be pulled out (Fig. 3). This supplies about 3½ in. of fore-and-aft freedom. The ends are shaped so that in the extended position they give about 3 in. of vertical freedom.

Allis Chalmers' Traction Booster

A Traction Booster shifts a portion of implement weight and tractor front-end weight to the drive wheels of the tractor to get more wheel traction. Tractors equipped with a Traction Booster system are said to do at least 20% more work than tractors not equipped with the system.

The most important factor effecting traction is the amount of weight carried on the drive wheels of a tractor. With the Traction Booster, when the drawbar load reaches a point where additional traction is needed to avoid excessive drive wheel slippage, a portion of the implement weight and the tractor front end weight is automatically transferred to the tractor drive wheels.

This weight transfer or boosting of traction is accomplished by supporting a portion of the weight of the implement on the hydraulic ram actuated lift arms of the tractor. As the traction requirements increase with an increase in drawbar load, the tractor load sensing spring measures this load and causes the hydraulic system to increase the amount of implement load supported by the lift arms. When this additional traction is no longer needed, most of the weight is automatically returned to the implement and the tractor front end.

A single-point drawbar hitch, together with proper depth adjustment on the implement, insures virtual constant depth of implement penetration regardless of weight transfer. The system maintains the desired working depth, yet responds immediately when more weight is needed on the tractor drive wheels.

Wheel weights add traction and permit the tractor to pull an implement through the tough spots in the field. But that added weight still has to be rolled along when not needed in the rest of the field. Therefore this added weight becomes excessive when

not required for traction. With the Traction Booster, when additional weight for traction is not needed, it is returned to the implement.

Fig. 4 shows the general arrangement of tractor and implement utilizing the automatic Traction Booster with the remote ram operating the transport wheel of the high-capacity implement. The system is quite simple and completely automatic. It merely consists of an extra valve in the Traction Booster hydraulic system which automatically directs the hydraulic fluid to a remote ram after the maximum weight transfer has been applied to the tractor drive wheels. As the hydraulic fluid is directed to the remote ram, the implement is lifted on its own wheel, or wheels as the case may be, thereby making it necessary for the tractor to carry only a portion of the implement weight during transport. This then provides the necessary transport stability to the tractor-implement combination and permits a given tractor to do the work of a much larger tractor that does not have a traction booster.

Fig. 5 illustrates schematically the main elements of the hydraulic system. Namely, the drawbar and drawbar pivot fork, which actuates both the load sensing spring, and the link rod, which operates the hydraulic pump. The pump then supplies the necessary control of the hydraulic fluid output to the tractor rams and the transport valve. The transport valve in turn controls the flow of the hydraulic fluid to and from the remote ram.

Consider now a tractor weighing 4600 lb with 1150 lb carried on the front wheels and 3450 lb on the drive wheels. This is typical of tractor design weight distribution where 70–75% of the tractor weight is on the rear wheels.

Not including dynamic effects, the maximum possible weight transfer to the drive wheels of the tractor, as controlled by the transport valve, is 1400 lb. As a result, under conditions of maximum weight transfer, the weight on the rear wheels may total as much as 4850 lb. This condition provides the same traction that would be obtained with a 6500-lb tractor not having weight transfer and makes practical the hitching of heavy, high-capacity implements in a manner which results in greater utilization of engine horsepower without an increase in tractor weight.

The 4600-lb tractor is capable of pulling, under most conditions, a four-bottom 14-in. moldboard plow with a small air-tired trailing transport wheel. The tractor-plow combination retains the maneuverability advantage of a fully mounted implement permitting sharp turns and course-changing ability, unrestricted backup, and safe rubber-tired transport. Since the implement is designed for a specific tractor, it permits minimum design allowance for dynamic loading and results in a tractor-implement combination of maximum operating efficiency.

In field operation as the plow enters the field, the tractor lift arms lower the load plow first, automatically followed by the remote ram lowering the rear of the plow. This acute angle entry results in quick attainment of full plowing depth together with unstaggered entry of the plow bottoms. Likewise, when the plow is lifted at the end of the field, the lead plow bottom raises first, leaving uniform, even-length furrows at the head lands.

To see better the work advantage of the Traction Booster, let's reconstruct an actual field demonstration made with the mentioned tractor-plow combination. The field is tough. It hadn't rained appreciably for two months. The demonstration is to show the difference in wheel slippage when the Traction Booster is not engaged as compared to when it is used. Also, depth measurements will be made to see if the unit plowed the same depth both times. One thousand feet are plowed without the Traction Booster engaged, in second gear, with three 14-in. bottoms at about a 9-in. depth. Without the

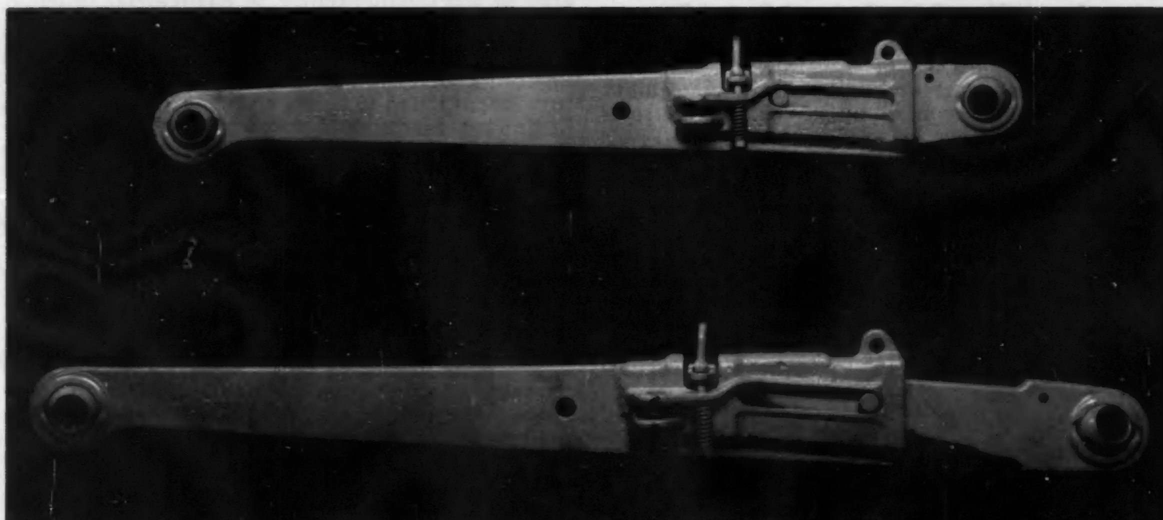


Fig. 3—Pull links with end in operating (top) and coupling (bottom) positions. This arrangement provides about 3½ in. of fore-and-aft freedom and 3 in. of vertical freedom. These leeways permit easier hookup of implement to tractor.

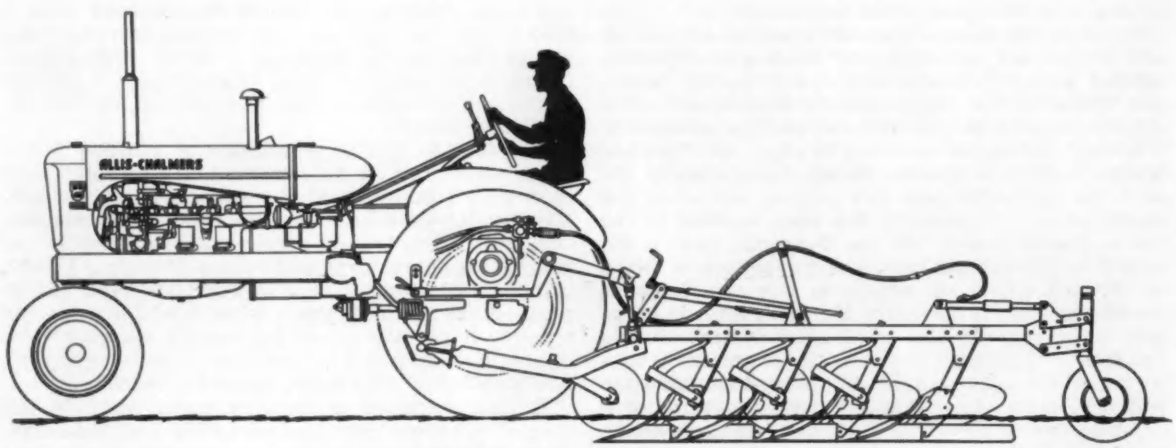


Fig. 4—General arrangement of tractor and implement utilizing Allis Chalmers' automatic Traction Booster with remote ram operating transport wheel of implement. Valve in Traction Booster hydraulic system automatically directs hydraulic fluid to remote ram after maximum weight transfer has been applied to tractor drive wheels. Fluid lifts implement on its own wheel, making it necessary for tractor to carry only a portion of implement weight during transport.

Traction Booster, it took 4 min, 35 sec. The furrow depths are measured at three locations. The first was 9½ in., the second 10½ in., and the third 9½ in.

The same run is reported in adjacent furrows with the Traction Booster engaged. In measuring furrow depths at the same spots as before, they were 9½ in., 9½ in., and 10 in., respectively—for all practical purposes the same depth as before. The time, 3 min, 19 sec, or 27.6% less time with the Traction Booster.

● John Deere's Three-Point Hitch and Control System

John Deere's new three-point attachment system permits the application of integral implements to the larger sizes of farm tractors. Interchangeability is achieved; and new concepts of control give suitable regulation of the hitch.

The hitch on the new John Deere 520, 620, and 720 series tractors is a three-point attachment system. It is similar to the three-point hitch with "load and depth control" found on the small size models, 40 and 40s. The new hitch, however, has been made adequate in strength to handle the larger implements that may be used with the new tractors. It also has numerous refinements to enable it to perform under a wider range of operating conditions.

A three-point hitch design was chosen for the new tractors because:

1. The use of virtual centers allows more freedom in basic tractor chassis shape; or conversely, given a tractor chassis of established configuration, it is possible to locate the linkage centers to obtain a desirable geometric arrangement. As is well known, this center of action has an important influence on trailing steadiness, ground entry, transport attitude, depth control of an implement, and weight transfer effects.

2. The three-point system lends itself to a load-sensing control arrangement which will give automatic regulation of working depth.

3. There is a large quantity of implements, tools, and attachments of almost endless variety now available for use with three-point hitch systems.

4. The trend is toward interchangeability in the use of tractors and implements. Only the three-point attachment system has achieved any large degree of interchangeability in commercial practice.

5. The attaching points for the three-point system are widely spaced. This promotes rigidity. The draft links and center link have tension or compression load applied to them, thus can be lighter than in designs which must resist the "tumblebug" action of the implement by using the hitch members as cantilever beams.

6. The three-point system lends itself to providing for all necessary adjustments for making the tool function properly. Fore-and-aft leveling is accomplished by changing the length of the center link. Lateral leveling is done by changing the length of one lift link. Adjustment of height range may be done by lengthening or shortening both lift links. Also, a lending adjustment for shifting the lateral position of certain implements may be provided. And lateral roll flexibility is obtained when desired with wide implements by removing two collars from the lift links between the lift arms and draft links.

Provision has been made for attaching both category 1 and category 2 implements to the hitch. The adapter assemblies consist of two sizes of pins and

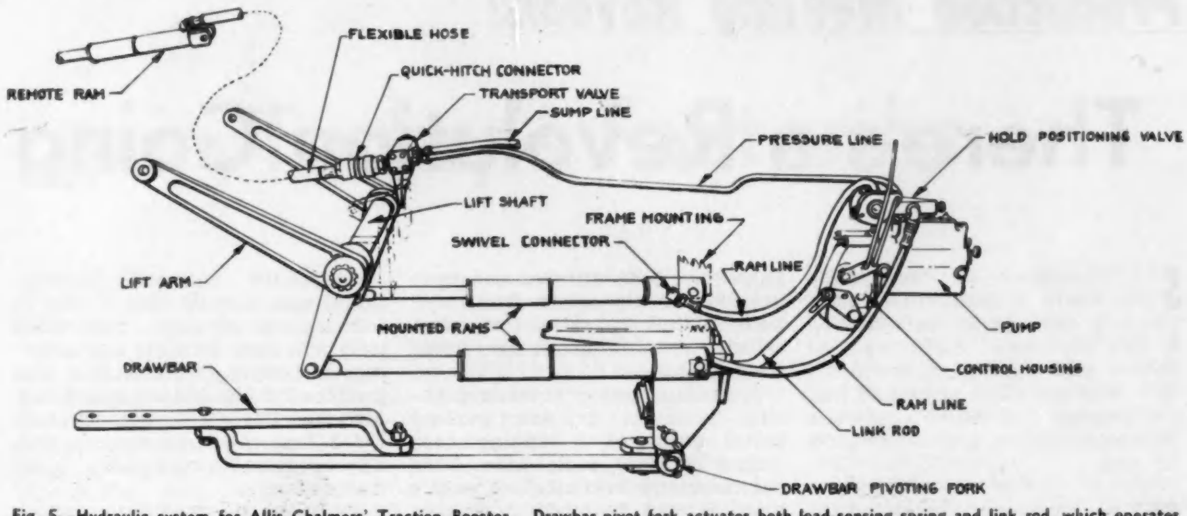


Fig. 5—Hydraulic system for Allis Chalmers' Traction Booster. Drawbar pivot fork actuates both load sensing spring and link rod, which operates the hydraulic pump. Pump then supplies necessary control of hydraulic fluid output to tractor rams and transport valve. Transport valve in turn controls flow of hydraulic fluid to and from remote ram.

corresponding balls to be installed in the implement mast, balls in the draft links which conform to category 1 length and category 2 hole size, and bushings for the category 1 implement hitch pins.

The matter of easy attachability becomes increasingly important as the tractor and its implements become larger and heavier. For tractors of 3-plow size and greater, it is not generally possible to attach a hitch-mounted implement by hand rolling the tractor or manually shifting the implement.

For implements built to use a loose hitch bar, the bar is attached to the tractor draft links and the tractor backed up to the implement so that a guide on the bar engages the jaws on the implement frame. "Quik-Tach" pins lock the bar in place. The top link connection is made by engaging the hooked end over the ball, which is installed in the implement mast.

For implements not arranged to use the hitch bar, attachment is facilitated by telescoping draft links, which obviate the need for exact fore-and-aft positioning of hitch points. Full-range adjustability of each lift link and of the center link, with indexing marks on each, aid in attaching without lifting or juggling implements.

• Hitch Control System

Provided with the three-point hitch is a hydraulic control system. The basic system consists of a large volume reservoir, a constant running pump (which can be shifted out of action), a position-responsive type large-capacity rockshaft located above and behind the rear-axle centerline, and a rockshaft control valve, along with the necessary plumbing and hardware. It is an open-center, medium-pressure system.

A load-sensing control mechanism is added to the basic hydraulic system for depth control of hitch-mounted implements. This control has been given the name "Load and Depth Control." It provides a load-compensated regulation of the position-responsive rockshaft; and with it, the hitch itself. This control is effective only when the hitch is used with ground-engaging implements. As is commonly known, these implements generate a "tumble-bug" action about the lower attaching points, due to soil resistance being applied to the implement at a point or points below these hitch pins. This tendency to rotate forward is resisted by the upper link, which is attached at its forward end to a movable yoke. This yoke is cushioned against deflection by a pair of compression springs.

Thus, for a given thrust load in the upper link, there will be a deflection of the yoke from its at-rest position. Movement of the yoke is transmitted through its mounting shaft to a servomechanism which provides the position-responsive control of the rockshaft. Variations in this thrust load will cause a shift in the position of the yoke; and with it, the height of the hitch.

The "Load and Depth Control" does not attempt to maintain a constant draft in varying soil conditions. What it does do is to adjust the working depth from the established position only enough to stay within the tractor-pulling capacity. This results in a uniformity of working depth approaching that of a constant depth system without the possible overload situations presented by the latter arrangement. The control response also prevents going excessively deep when a soft spot is encountered in the field. As compared with a pure draft-responsive system, the regulation results in substantially less variation from the desired depth when operating in a field having varying draft conditions.

Production Meeting Reveals:

There's a Revolution Going

SAE President W. Paul Eddy overheard a production man's uniquely descriptive classification of SAE members—engineers concerned with the design, manufacture, and operation of ground and air vehicles. You might label them Dreamers, Doers, and Destroyers, he said.

* * *

THE nearly 400 who attended the SAE National Production Meeting in Buffalo, March 20–22, might well have disagreed with the above classification. They saw and learned that the doer-production men are dreamers, and they're making their dreams come true. The revolution taking place in today's factories is rife with excitement for manufacturing men. They have put to work science, research, and development (plus their fertile imaginations) to harvest a new and profitable crop of ideas that are beginning to pay off.

Steel machining chips transformed into useful parts, machines operated by electronic brains, new tool materials that save precious lead time and cut costs . . . these and a host of other creations of the production man's imagination are yesterday's dreams reaching reality today.

The three-day information interchange—in technical sessions, Production Forum panels, and on plant trips—brought to light new developments in:

1. Materials for tools.
2. Machines and equipment for automotive plants.
3. Methods and approaches to automotive manufacture.

Some one must have heard manufacturing men gripe that "chips are our most expensive product"—and did something about it. "Why not make something useful from this waste?" he asked. And that's just what process researchers at General Motors have done.

One of them told how steel chips have been sintered and compressed. Parts made from this material have physical properties closely resembling those made from mill steel.

Aluminum oxide, another plentiful material, is now making metal chips as a cutting tool. These ceramic tools have been commercially available for only a year, it was reported, and they are cutting metal faster and better. Oxide tools work best at cutting speeds 2–10 times those of conventional cutting tool materials. They're easier to grind and are said generally to produce better finishes.

The entire potential of oxide tools won't be realized until machine tools are built that can fully use them. It took the machine tool industry 20 years to catch up, and then surpass, carbide tools. Now the oxides again have put cutting tools ahead of machine tools in terms of capability.

High-speed steel tools also have been improved, a metallurgist noted. Additions of molybdenum and vanadium to high-speed steels have made them harder and more abrasion resistant. Tool life has been improved 30–50% in some cases.

Vanadium also is playing a prominent role in a new die steel. Called Ottawa 60, this material contains 12% vanadium and 3¼% carbon. Its toughness, high wear resistance, and low coefficient of resistance are winning for it applications in drawing of stainless steel. Ottawa 60 also has proved satisfactory in trim dies, and in working on a number of different materials.

General Motors has developed a new die material that gives a die life between that of conventional zinc-base tools and ferrous dies. Nickel and titanium alloyed in a soft zinc matrix form hard particles and furnish this material, called GMOODIE, with its wear resistance.

GMOODIE outwears conventional zinc dies by four to one in forming 18–20-gage cold-rolled steel. In light forming and drawing operations, the material can produce 100,000–200,000 stampings. Although GMOODIE tools cost only 1/4–2/3 as much as ferrous dies, they require considerably more maintenance.

High on the production man's dream list are metal adhesives. They're on the way, those at the Meeting learned, and will in the not-too-distant future be used in assembling aluminum die castings and applying metal body trim. Even though they won't replace conventional metal joining processes such as welding, brazing, and soldering, these adhesives will find wide application.

Electron Invades the Factory

To the "bull-of-the-woods" production man, discussions at Buffalo would have sounded as if factory men have gone long-haired. Electronic brains and automatic mechanical muscles are being installed in automotive plants as fast as these new devices prove themselves.

A progress report on electro-machining revealed that the process is becoming increasingly more practical. In this method an electrical current shapes the work piece. The desired shape to be cut is defined by the shape of the tool, which also disintegrates as the work is "machined." The technique already is being used to produce die cavities, to sharpen tools, form surface contours, and to pierce, tap, trepan, and drill.

Much of the interest at the Meeting centered around cold extrusion. Proponents of the process say, "It's cheaper to move metal than to remove it." Cold extrusion will make increasingly greater inroads as more manufacturing men learn how to use it. Right now it takes more than just

on in Today's Factories

one part to justify a manufacturer's investment in phosphating, annealing, and press equipment.

Another piece of "blue sky" that has come to stay is computer controlled machine tools. The Forum panel on this subject brought together physicists and mathematicians swapping experiences and information with the production-doers who want to get things made cheaper and faster.

These men told how in some cases a computer is used to calculate the design of production tools such as cams and dies. In other cases, the computer is combined with the machine and completely fabricates a part from the intelligence it picks off a punched tape.

Time requirements that may have sounded fantastic a few years ago are commonplace today in operations using numerical control. For instance, given the equation and drawing for a simple cam, you can program it on tape in 20 min using a computer, and machine it in 5 min on a numerically controlled machine tool.

These machines still don't fit the pocketbook of every plant. The economics of their use depends on the part to be machined, its complexity, and cost. They still come too high for most machining jobs because their development cost has to be borne by today's customers.

Electronic equipment is important to automated lines in more ways than are obvious. In maintenance of automation equipment, for example, a 14-channel recorder recently developed can be plugged

THE NATIONAL PRODUCTION MEETING was organized under the leadership of General Chairman Elmer Olson.

THE MEN WHO LED the Production Forum in Buffalo are (left to right) Chairman Churchill Bartlett and Co-Sponsors W. E. Wilson and P. H. Rutherford.

SAE Vice-President for Production, D. S. Kimball, Jr. (left) with J. E. Adams, Meetings Vice-Chairman of the Production Activity Committee, reviewed the content of the Buffalo Meeting to determine areas worth further exploration by the Production Activity.

ALL OF US can think creatively, but most of us have built-in inhibitions which prevent us from doing so most of the time. That's what was said in Buffalo by luncheon speaker Dr. Sidney J. Parnes (left), who was introduced by Toastmaster E. D. Rollert.

into an automation line to check the operation of the machine against a master chart. By quickly showing the cycle time on each operation, this device is a shortcut in trouble shooting.

Another piece of automated equipment that drew interest was a robot-arm universal transfer machine. This arm can swing 360 deg, raise or lower 2 ft, and bend at its elbow. Its motion pattern can be varied by feeding intelligence into its computer control mechanism. It's being used to feed a punch press and to remove parts from a die casting machine.

Yet another innovation in automated equipment is the remote-controlled tractor-trailer trains for moving materials in a plant. A wire in the floor or ceiling establishes the train's path without contacting it.

Automation Realities Emerge

Production men who have several years of experience with automation gave some practical slants on what it takes to live with automation. For instance, automated assembly machines demand pretty close to 100% quality, they said. Assembly machines can't readily allow for variations. So in some cases even 1% of parts out of tolerance can be costly.

It's been found, too, according to reports at the Meeting, that you can't just automate a single part or a section of a line and realize any savings. You have to automate a complete line to get any value from automation.

And an experienced hand at setting up automated lines urged production men to design four or five alternative processing methods and to select the best. Just don't design one method and then tool up for it, he warned. Your investment is too costly to buy the first approach that comes to mind.

Several Canadian production men explained their attitude on automation. Because their volume is lower than it is in this country, they can't afford fully automated equipment. So they start with a machine that's about 75% standard, and then they adapt it to special attachments.

Furnas Fixes Research-Production Relationships

Many automotive companies, reports at the meeting showed, have already carried out the suggestion

JUST BEFORE THE LUNCHEON on the first day of the Production Meeting, luncheon speaker C. C. Furnas, Chancellor of the University of Buffalo, (second from right) gave a preview of his remarks to (left to right) Buffalo Section Chairman A. H. Gille, SAE President W. Paul Eddy, and Toastmaster Ira G. Ross.

made by Luncheon Speaker C. C. Furnas, chancellor of the University of Buffalo, that:

"Production organizations should have groups to carry out their own investigation for those forms of improvement which logically fall in the general bailiwick of production. . . . A certain degree of autonomy of production units for delving into their own problems is essential for a vigorous and advancing organization."

As the sort of thing particularly adaptable to working out by "an alert investigation production group," Furnas suggested:

- Better methods of fabrication with given materials.
- Product reliability.
- Improved design of production machines.
- New and ingenious methods of materials handling.

"As automatic production methods come more into prominence," Furnas concluded, "I foresee an ever-rising, ever-increasing importance in research and development in production methods.

"This may take the form of that analytical approach based on mathematical thinking known as 'systems analysis' . . . or the more sophisticated activity usually called 'operations research.' So don't be surprised if, in the future, you see more and more long-haired mathematicians probing into the details of production methods and processes. Don't resent and ignore them."

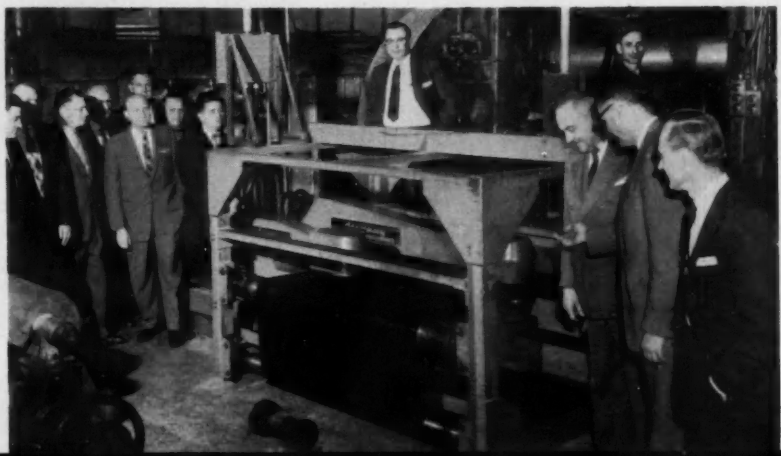
Leading up to these conclusions, Furnas warned that production only comes into the picture after the research and development process has been carried out. True, the new material or device serves no useful purpose until production is under way. But, he said, research and development is a continuous spectrum and must be carried along a substantial distance before production comes in. He also brought out that:

A development item must eventually be weaned away from research and turned over to those who are going to produce it. This is often difficult to do, because the research-centered mind seldom wants to give anything up. It is always seeking perfection. . . . Hence management has the continuous task of effectively and smoothly merging the newly developed item into the production picture.

Furnas pretty well summed up the production excitement generated at the Meeting when he said:

"Despite the fact that the history books record that the Industrial Revolution was something that came in with the development of the steam engine and then was finished in the Nineteenth Century, it is my contention that the Industrial Revolution is just now getting well started."

SAE FIELD TRIPPERS at Dunlop Tire & Rubber Corp. plant inspect the AccuRay, an advanced atomic measuring device. Through the use of this machine the exact amount of insulating rubber coating required to protect the nylon or rayon ply cord to within a thickness of ± 0.001 in. is applied.



How Rohr Aircraft Makes High-

ROHR is fabricating a number of sheet-plus-honeycomb sandwich structures by a furnace brazing technique. The illustrations on these pages show how it is done.

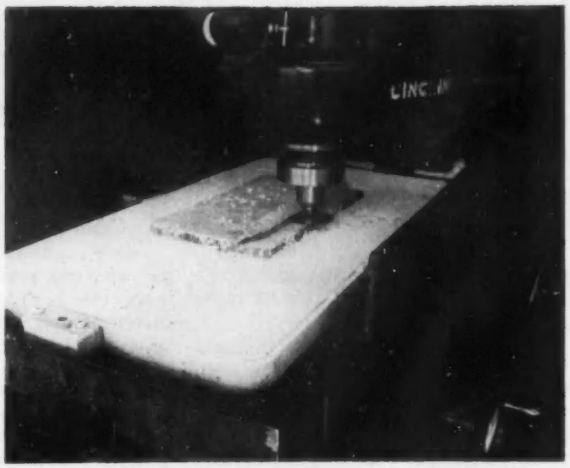
Among the parts now in production are:

- Contoured shear panels for powerplant support strut.
- Tapered elevons.
- Flat trailing edge with numerous inserts.
- Airfoil sections of a Canard wing.

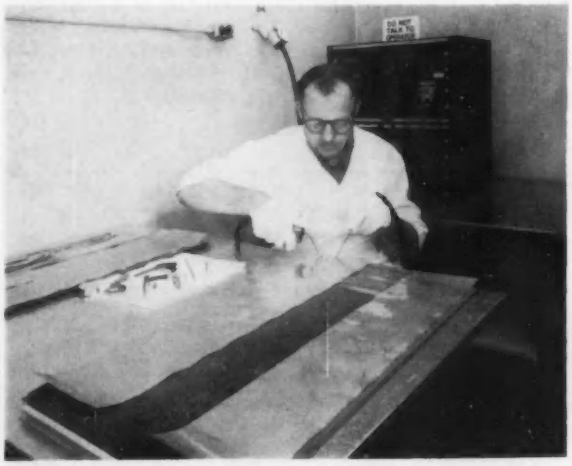
The success of the process depends on extremely careful handling and proper detail at the very outset. Shown here are design hints on what to do and what to avoid when handling edge members, shear attachments, and knife edges.

Looking to the future, Rohr sees the development of titanium sandwich structures, a sandwich structure for operation in temperatures up to 1500 F, and another for operation above 2000 F.

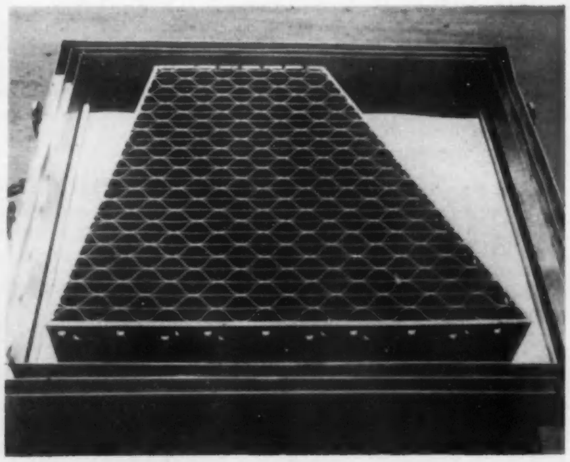
(Paper, "High-Temperature Sandwich Structure —Present State of Development and Outlook for the Future," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers.)



CORE is machined to precise dimensions and given an initial cleaning to prepare it for pre-fit assembly. To maintain cleanliness, parts are handled with white gloves throughout assembly.



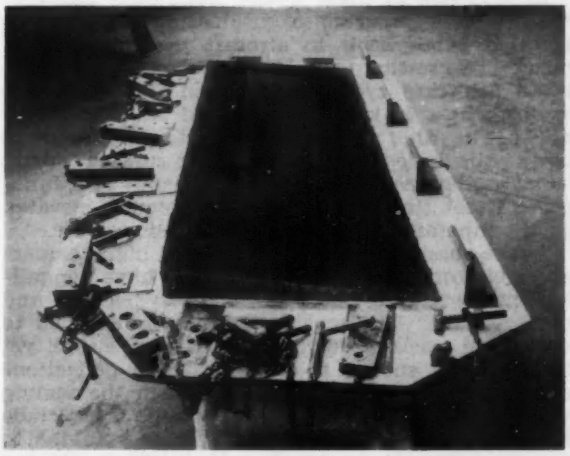
TACKING a typical panel. Assembled panels are held together with tie strips, and are accurately located and tack-welded to the brazing fixture, together with appropriate test coupons.



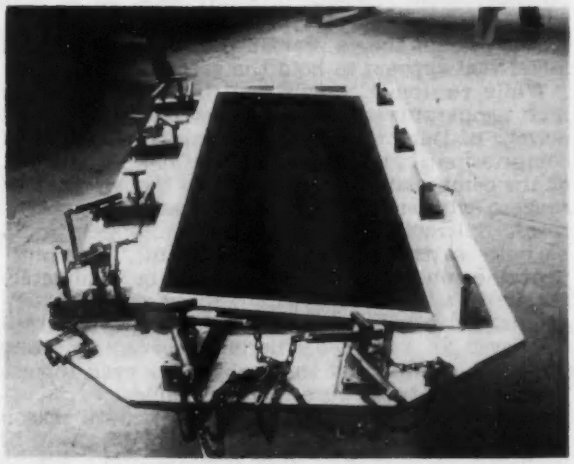
TYPICAL BRAZING FIXTURE for a sandwich structure. A diaphragm is welded over the top of the brazing fixture. The fixture is thoroughly purged with dry argon before charging into the furnace.

Based on paper by **H. M. Rush,** Rohr Aircraft Corp.

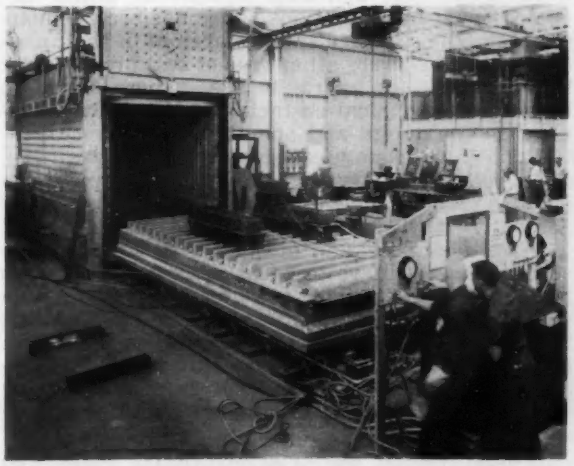
Temperature Sandwich Structure



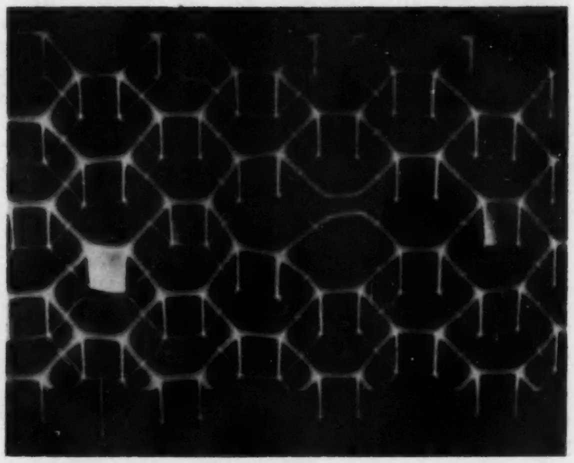
DETAILED PARTS are assembled into kits and given a prefit assembly to determine matching of the parts, then transferred to final assembly. Here is the assembly fixture with core in position.



ASSEMBLY FIXTURE with core and channels added. After careful and accurate assembly to complete the panel, it is tack-brazed on this special fixture. Before final assembly parts must be very carefully cleaned.



CHARGING BRAZING FIXTURE into furnace. Brazing is done with dry argon flowing through fixture and a partial vacuum is maintained to hold detail parts in contact and to hold the panel solidly against the fixture.



PANEL looks like this when examined radiographically to evaluate continuity of bond. Work is being undertaken to evaluate and correlate fluoroscopic and ultrasonic methods of inspection.

Metal Seals . . .

. . . are expected to succeed rubber O-rings in aircraft hydraulic systems subject to thermal cycling and possible nuclear irradiation.

Based on paper by **George R. Keller and Paris H. Stafford,** Autonetics Division, North American Aviation, Inc.

THE usable range of temperature and thermal cycling of elastomeric seals appears to have been exploited to the full. Added requirements in terms of higher temperatures, greater temperature range, increased rate of thermal cycling, and resistance to nuclear irradiation will probably have to be met with seals of metal or other non-organic material. At the present time a preloaded, pressure-energized metal seal appears to hold the greatest promise.

While elastomeric seals can probably withstand high temperatures and high pressures for extended periods of time, these seals all exhibit pronounced compression set under these conditions. The effect of the compression set is to reduce the installation squeeze, with subsequent seal leak at low temperatures. Therefore, an elastomeric seal which would be quite satisfactory for a supersonic intercontinental bombardment missile could be completely useless in a short-range, high-speed piloted interceptor. Likewise, a seal which would perform properly over an extended, thermally severe one-way flight could fail under thermal cycling even though peak temperatures were relatively mild.

There is another, as yet less well-known, reason for considering the use of metallic dynamic seals in both missiles and inhabited aircraft. The life of familiar elastomeric compounds may be quite short when subjected to nuclear irradiation. Although this field has not been thoroughly analyzed, it does appear that nuclear-powered aircraft and missiles which are subject to atomic counter-measures may not be able to rely on elastomeric pressure seals.

Piston-ring seals in many forms are being tried in aircraft hydraulic systems, but the working pressures—3000 psi and up—are more severe than those for which piston rings have been successful in the past. Hydraulic power also is being used to operate flight control systems, but where they incorporate high performance servomechanisms, the leakage often associated with piston rings becomes intolerable. On that account, a metallic dynamic seal superior to the piston ring may be needed for very modern aircraft which use high-performance stability augmenters and automatic pilots.

Where the seal separates pressurized fluid from air, any significant leakage past the seal will create a severe fire hazard. In many of the newer airborne weapons, the fluid may have to operate at temperatures in excess of its flash and fire points. At the same time, the compartment temperature might be in excess of the autogenous ignition temperature of the fluid. External leakage under these conditions would result in the loss of the aircraft by fire.

Metallic Seals Needed

There is a real need for a metallic seal which will operate satisfactorily at temperatures well in excess of 500 F, which will contain pressures greater than 3000 psi, be capable of enduring a large number of thermocycles, and have leakage characteristics and service life at least as good as the O-rings in today's aircraft.

In response to these needs, Autonetics has embarked on a program of evaluating and testing metal dynamic seals in aircraft hydraulic equipment. Two testing techniques are being used. One is an arbitrary cycling at a fixed frequency and stroke where leakage is measured as volume per cycle. The other method attempts to simulate more closely the duties of an actuator in a surface control servomechanism. Here, leakage can only be a function of test time. With both techniques, elevated fluid temperatures result in shortened seal life.

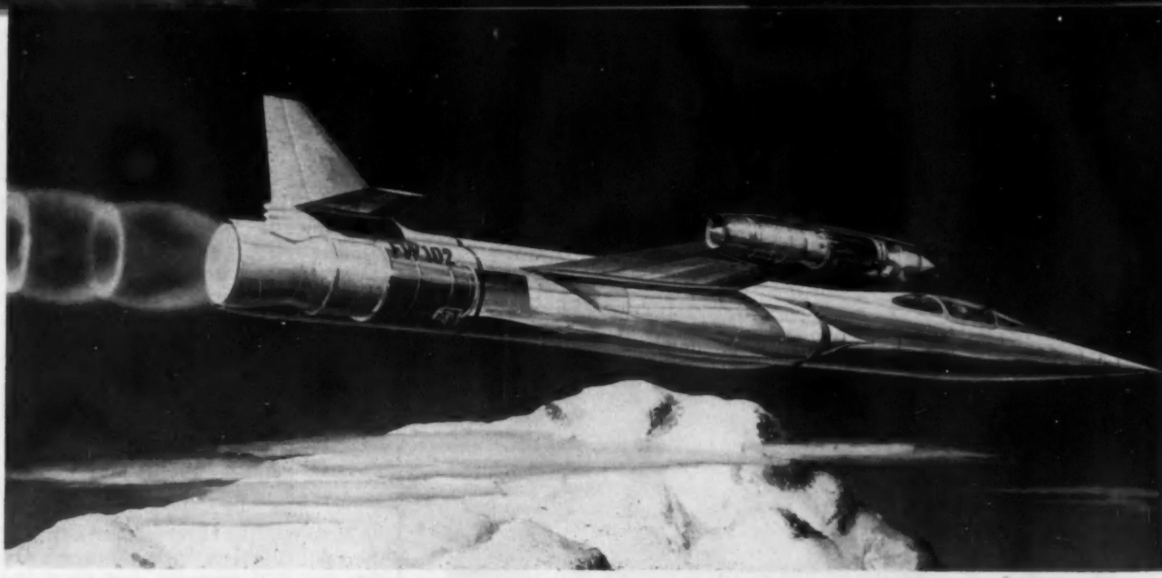
In the absence of fluids having good high-temperature viscosity, seal materials should have nongalling characteristics, be strong, highly elastic, and not too hard. The seal itself must be designed to withstand excessive deflection under pressure, yet be compliant enough to compensate for deflections of its mating surface. Forces between the sealing surfaces should always be great enough to preclude leakage at low pressure and never so great as to squeeze out all of the thin film of oil when activated by high pressure.

High Precision A Requisite

Metallic dynamic seals can be made to operate in working aircraft hydraulic equipment under expected operating conditions. This has been demonstrated. The seals are as yet marginal in their usability, but so is every other type of seal proposed for high-temperature hydraulic use. There seems to be no basic technical obstacle preventing improvement in the design and operation of these seals.

When a completely satisfactory seal is available, the aircraft industry isn't going to be happy with it. The seal will have to be matched to a particular actuator. It will be a precise device, manufactured to close tolerances, and finished with a mirror-like surface. It will have to be handled like a precious jewel. It will be capable of giving good service only when operating with hydraulic fluid of fantastic cleanliness. It is not going to be an item which can be serviced at an advance military base. The requirements of the new weapon systems, probably will leave no choice as to whether or not it will be used.

(Paper, "Metal Dynamic Hydraulic Seals," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)



PLANE FOR MACH 2-4 REGIME has ramjet in fuselage and turbojets at wingtips, as conceived by artist.

SPRING AERONAUTIC MEETING DISCUSSES FLIGHT at Mach 2-4 and 50,000-90,000 ft

PILOTED airplanes flying at speeds of Mach 2–4 and at altitudes of 50,000–90,000 ft are currently the concern of many in the aviation industry . . . even while others are still struggling with the problems associated with high-subsonic transports. A wealth of information on both topics was exchanged at the SAE National Aeronautic Meeting held April 2–5 in New York.

The four days of the Meeting were headlined:

April 2—Aeronautic Production
April 3—Aircraft Propulsion
April 4—Air Transport
April 5—Military Aircraft

The Aeronautic Production Forum is reported on pages 84–86 of this issue. Many of the engineers and executives who came to attend the Forum's clinics stayed over to join the hundreds who came for the Meeting's three subsequent days of technical sessions on design and operating problems . . . and for the 58 exhibit booths in the SAE Aircraft Engineering Display, the daily luncheons, and the concluding Sky Ball held Friday evening, April 5.

The Meeting drew a higher pro-

HARD-WORKING GENERAL CHAIRMAN A. T. GREGORY (right) receives plaque from SAE President Eddy in appreciation of his services in organizing the Meeting. Gregory is chief engineer of the Fairchild Engine Division.

Aircraft Propulsion Day Luncheon

RELAXING FOR A MOMENT before Aircraft Propulsion Day luncheon are toastmaster H. Mansfield Horner and speaker E. R. Sharp. Horner is chairman of the board of United Aircraft Corp. and Sharp is director of the NACA's Lewis Flight Propulsion Laboratory.

PROPULSION IS THE KEY TO AVIATION PROGRESS just as "Aviation Progress is the Key to Survival" as the Meeting's theme ran. This was luncheon speaker E. R. Sharp's thesis, and he backed it up with the reminder that every successful airplane since the Wrights has been built around an available successful propulsion unit. Sharp made these observations:

- A propulsion system combining both turbojet and ramjet could prove to be ideal for a supersonic transport.

- Possibility that a suitable ducted fan engine or rocket propulsion system will eventually supplant the turbo-ramjet or straight turbojet will depend on the rapidity of developments in the field of noise suppression and overall safety, especially in the case of rockets. But rockets will eventually enter the field of transport propulsion.

- High-energy fuels may be expected to find maximum use in turbojets for high-speed military aircraft. These fuels will insure efficient combustion at extreme altitude and achieve maximum supersonic radius. Take-off and cruise requirements may dictate the need to design for dual fuels.

- For extreme altitudes, auxiliary rockets may be used to furnish the stream in which jet-reaction controls will operate.

- Due to increasing speed requirements, ramjets will probably lose out to rockets in missile designs. But first we must solve the problems connected with precision in propellant feed rate, complete propellant utilization, maximum nozzle effectiveness, damping of combustion oscillations, and surface cooling. Once these problems are solved for rockets, the solutions can be applied advantageously to other types of powerplants too.

portion of out-of-town participants than previous New York Aeronautic Meetings, despite the bad flying weather prevailing throughout the week. Both out-of-town and local participants appreciated the SAE Meetings Committee's action in moving the Meeting to the Hotel Commodore, where almost all sessions could be held in the three ballrooms and seven parlors located on one floor.

Powerplants

Noting that three of the century series fighters now flying are Mach 1.5–2 aircraft and that the X-2 reached "well above Mach 2.5," speakers at Aircraft Propulsion Day went on to speculate about powerplants and materials for the Mach 2–4 range. Two ways of propelling a plane at these speeds were brought out:

1. Small turbojets having high thrust/weight ratios.

2. Combinations of turbojets and ramjets.

Rockets were discounted for the next decade, mostly because of their transient problems. However, research is under way now that ought to give us, well within 10 years, turbojets delivering 2000 lb thrust for an engine weight of 130–180 lb and at a specific fuel consumption of less than 1 lb fuel per lb thrust-hr.

Small turbojets were said to be more promising than big ones for supersonic flight. The concept that engine weight increases as the volume or cube while air-handling capacity and therefore thrust increases as the area or square of dimensions does not hold strictly, it was agreed. (You can't scale down tip clearances, tolerances, and engine controls, for example, below certain minimums.) But optimum thrust/weight ratios and engine-plus-fuel weight/vehicle weight ratios occur with turbojets much smaller than today's 10,000 lb thrust types, speakers indicated.

Low Pressure Ratios

Supersonic turbojets will probably have pressure ratios between 4 and 7, indications are. That's to achieve good fuel economy and consequent low engine-plus-fuel weight/vehicle weight. Low specific fuel economy results from

low engine pressure ratios and low turbine inlet temperatures. Unfortunately, so does low specific thrust—and large frontal areas, and therefore large drag, result from low pressure ratios. Ratios in the 4–7 range appear to be a good compromise.

Turbojet-powered planes for the Mach 2–3 regime would probably have enough thrust to give them vertical take-off and landing capabilities at sea level, the experts predicted.

Turbo-Ramjets

Propulsion systems combining turbojets and ramjets probably wouldn't have this VTOL capability. But they could be pushed to Mach 4 at 90,000 ft altitude, according to analytical data presented. The turbojet might be installed in the fuselage and the ramjets at the wingtips—or vice versa. Or the turbojet might be installed inside the ramjet, all in the fuselage, like the French "Atar" fighter now flying.

In connection with the ramjet-turbojet proposal, it was noted that supersonic aircraft can get into varieties of trouble never dreamed of with the familiar subsonic types. Supersonic craft can zoom to altitudes where the usual controls are ineffective—where only jet-actuated controls can get a grip. They can dive to speeds where the dynamic pressure loads, assisted by high temperatures, make any flyable structure inadequate. For these reasons, supersonic flight must be restricted to a rather narrow range.

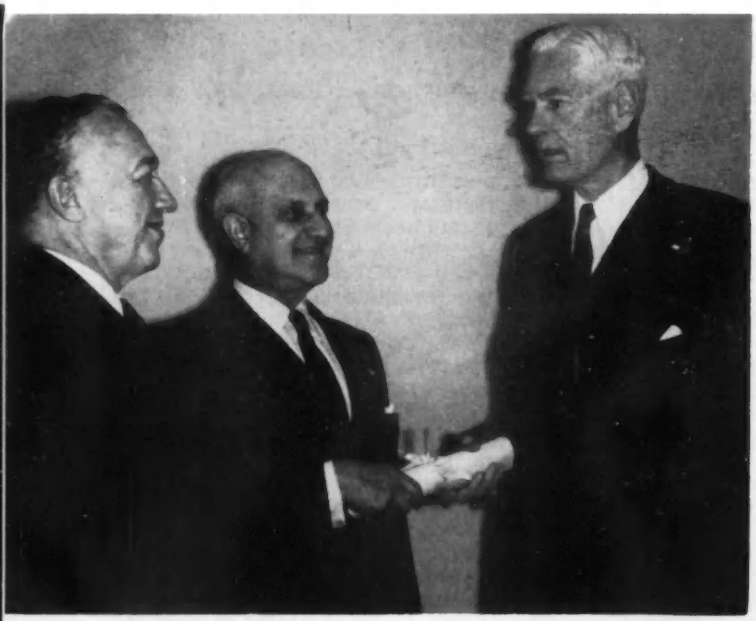
The thermal barrier to supersonic flight was mentioned often at this Meeting but not so awesomely as at similar gatherings in previous years. One man compared it to a big rubber ball: it's not too difficult to nose into it and back out again, but it takes a lot of effort to stay in it. That's because, as has long been recognized, the hot air in the boundary layer heats the airframe roughly as the first power of the air temperature —and that can be high. But, as has more recently been confirmed, the airframe immediately begins to radiate heat away roughly as the fourth power of its skin temperature. The result of these effects and others is that the airframe heats up gradually. Nevertheless, skin temperatures soon reach 500–1000 F—uncomfortably hot for materials as well as for men.

For this reason, airframe designers are turning from aluminum and magnesium to stainless steel and titanium—materials formerly used only for hot parts of engines. And engine designers are turning to still more heat-resistant materials, like coated molybdenum. This metal has high strength at high temperatures if it is prevented from oxidizing. Inconel-clad molybdenum turbine nozzle blades have given encouraging results in engine tests where they operated in 1800 F gas. Work is now in progress on molybdenum-base alloys said to retain their strength well above 2000 F with proper surface protection.

High-Energy Fuels

Papers on engines for supersonic flight made no mention of fuels. But in the talk fests they stirred

FRIENDS OF SAE PRESIDENT W. P. EDDY greet him just before he leaves with procession for speakers table at Aircraft Propulsion Day luncheon. All are executives of United Aircraft Corp. or its divisions. They are L. C. Mallet (left), L. S. Hobbs, Eddy, H. Mansfield Horner, and Earle Martin. Eddy, who is chief of engineering operations at UAC's Pratt & Whitney Aircraft Division, and Horner, who is chairman of the board of UAC, both took part in the luncheon program reported opposite.



HARRY F. GUGGENHEIM (center) accepts the Flight Safety Foundation, Inc., certificate of the Laura Taber Barbour Award from J. Carlton Ward Jr. (right), Chairman of the Award Board. Dr. Clifford E. Barbour Sr. (left), award donor, looks on.

The award, in honor of the memory of Laura Taber Barbour who died in 1945, was created to recognize notable achievement in the promotion of safety in flight.

The award, which consists of a gold medal, a certificate, and a cash honorarium, was presented at the SAE Air Transport Luncheon.

SAE'S WRIGHT BROTHERS AWARD was presented to Charles H. Zimmerman (right) for his paper "Some General Considerations Concerning VTOL Aircraft" presented at the April 1956 SAE National Aeronautic Meeting. This paper was adjudged by the Wright Brothers Medal Board of Award as the best contribution on an aeronautic subject presented at an SAE meeting during 1956. William B. Bergen (left), chairman of the 1956 Wright Brothers Award Board, made the presentation.

Zimmerman, one of the pioneers of VTOL aircraft, was recently appointed to a two-year term on the Army Scientific Advisory Panel by Wilber Brucker, secretary of the Army. (Additional information on the Wright Brothers Award can be found on p. 90 of the April, 1957 issue of SAE Journal.)

MRS. NORMAN PATCH (CENTER) AND MRS. ANN RENTSCHLER ACCEPT THE DANIEL GUGGENHEIM MEDAL and Certificate of Award, awarded posthumously to Frederick B. Rentschler, from SAE Past-President Edward P. Warner, Chairman, 1956 Board of Award. Mrs. Patch and Mrs. Rentschler are Rentschler's daughters. The presentation was made at the SAE Aircraft Propulsion Luncheon.

Rentschler was among the first to conceive of the aircooled radial engine as a major contributor to the solution of aviation's powerplant problems.

That was in the early 1920's. Twenty-five years, and several hundred thousand engines later, the output of the aircooled radial had increased from 200 hp to 3000; and the engines that Rentschler had inspired were powering a large proportion of the world's airliners.

At that point, in effect, he began again. The coming of the turbine brought new methods, new possibilities, and new problems. Such were Rentschler's versatility, adaptability, and engineering and managerial capacity, that within a few short years he became a leader in the new art as he had long been a leader in the old.

This is the first time that the Daniel Guggenheim Medal has been awarded posthumously. The Board of Award, in making its decision, wished to pay tribute to the memory of a great leader of the aeronautical world and a great contributor to its development. (Additional information on the Guggenheim Award can be found p. 90 of the April, 1957 issue of SAE Journal.)

up around luncheon tables and at other gathering places about the Meeting, the guesses were that high-energy fuels—probably those coming from the newly announced boron-processing facilities or fuels incorporating powered aluminum or magnesium—were assumed for the turbojets and the ramjets.

The papers on supersonic engines also stimulated airline engineers to engage in corridor conversations about huge supersonic transports powered by maybe several score of the little turbojets. They weren't entirely kidding, either. They explained that just stepping over from the subsonic to the low supersonic range of speeds isn't wise. Local airflows are in the difficult transsonic range until airplane speed is around Mach 1.4. And to reap real economic advantage, studies show, transports will have to cruise at Mach 2 or better.

That day is, of course, far beyond the coming generation of high-subsonic transports. Yet there will probably not be economic justification for an intervening generation of transports. So the soon-to-be-delivered transports like the Boeing 707 and the Douglas DC-8 are expected to be flying for a long time—maybe 100,000 hr, which is twice what even most long-service DC-3's have logged today.

Frangible Turbine Blades

That's why airline engineers were so interested in developments like frangible blading for an air turbine drive. If a blade fails in fatigue—or for any other reason—and part of it leaves the wheel, the imbalance and perhaps the flying fragment cause the remaining blades to sheer off at the pins that fasten them to the disc. Because the blades are small and made of titanium to keep them light in weight, their fragments have little kinetic energy and are easily contained in a thin, lightweight shell. There's no danger of a bursting turbine injuring humans aboard or damaging airplane structure, yet there's no weight penalty.

Of course, there was constantly implied recognition of the need for reliability as well as provision for safety in case of failure.

The bypass engine as exemplified by the Rolls-Royce Conway was recommended on the basis of

Air Transport Day Luncheon

J. H. CARMICHAEL addressed the Air Transport Day luncheon on the subject of "Turbine Transport." He was introduced by toastmaster Stuart Tipton, president of the Air Transport Association.

CAPITAL LIKES ITS VISCOUNTS, emphasized J. H. Carmichael to his audience at the Air Transport Day luncheon. Besides being moneymakers, the turboprop-powered, British-built airplanes are easy to fly, cheap to maintain, and favorites of pilots and passengers, he said.

Every profitable mile Capital Airlines flew in 1956, according to Carmichael, its president, it flew with Viscounts. Capital made a profit of almost $3.7 million with its Viscounts, even though it wound up $2.8 million in the red for the year's overall operations. Direct operating cost for the Viscounts was 76¢ per mile; indirect operating cost was 69¢ per mile. Break-even load factor was 54.1%—or 23.8 passengers.

As of April 1, the 60-odd-plane fleet was averaging 8 hr and 41 min per day utilization, despite the high weather minimums in force while flight and ground crews are getting used to the new equipment. Time between overhauls for the Rolls-Royce Dart engines is now 1500 hr, and Capital is in the process of obtaining CAA approval of 2000-hr intervals. The engines' manufacturer has approved 2200-hr intervals.

As of March 1, the airline had flown 474,000 hr with the Darts and had not once had to tear down an engine because of a failure. In that period of operation, only 32 prop featherings—three of them due to flame tube failures—had been experienced. Only 19% of the mechanical delays suffered by the Viscounts were attributable to the engines, Carmichael said. He added that in his line's newest piston-engine type, 57% of the mechanical delays were attributable to engines.

Over 600 Capital pilots have been checked out on the Vickers-built Viscount. They report it has good "feel," is maneuverable, responsive, easy to handle in bad weather. They appreciate it that the pre-take-off checklist has only 84 items—instead of the 104 items for the planes most of them had been flying previously. Trans-Canada Airlines helped with the training of both pilots and maintenance personnel, Carmichael said.

For added passenger comfort on the ground, Capital has added a freon cabin cooling system and Janitrol heaters. Copper brake plates gave trouble, so the heavier steel plates are again in use. After the Viscount accident in England on March 14, Capital inspected the flap attachment bolts of all 29 of its Viscounts that had reached a certain range of flying hours. The whole program took only 72 hr, Carmichael noted proudly.

Military Aircraft Day Luncheon

JUST ABOUT TO TAKE OVER PODIUM is Rear-Admiral Rawson Bennett (left), who was introduced by toastmaster Dr. C. C. Furnas, chancellor of the University of Buffalo.

SPEAKING ON "SCIENCE, SPACE, AND SATELLITES" Rear-Admiral Rawson Bennett, chief of the Office of Naval Research, told guests at the Military Aircraft Day luncheon that the Vanguard Project's earth satellite will tell us much about our planet and the region of space it inhabits.

Tracking the satellite may give us better measurements of the size and shape of the earth and distances between points on the earth, he said. A second output of the tracking program will be measurement of the drag on the satellite. From this, we should be able to figure out the density of the atmosphere at that height.

To evaluate temperatures on the outside and inside of the satellite, miniature temperature gages have been designed that can evaluate temperature changes from 300 F down to −220 F, Bennett revealed.

There's a limit to how much instrumentation can be crammed into a sphere less than 2 ft in diameter, Bennett observed. But the preparations for placing one earth satellite in orbit can be used for subsequent ones instrumented to send back additional data. Ultraviolet and x-rays from the sun, for example, could be obtained and compared with weather conditions on earth to see if there is any apparent correlation. Measurements of the earth's magnetic field above the atmosphere could be taken to provide knowledge important to radio communications.

Engineers have already moved into the Air Force Missile Test Center in Florida to set up equipment, Bennett said. Soon they will begin tests that will lead to a satellite launching attempt. In fact, the first series of test rockets has already been fired.

Soon we will actually be exploring the world of space, the Admiral promised.

expected superior reliability as well as lower fuel consumption by two of its proponents.

Discussions of jet reversers gave airline engineers assurance that adequate thrust braking systems for their turbojet aircraft would be available by the time jet transports are ready for service.

Turbine Fueling Facilities

Facilities for handling turbine fuel at airports will have to be somewhat different from those for aviation gasoline. That's because in turbine fuels, contaminants settle more slowly and because turbines have an even lower tolerance for water than piston engines do. Three suggestions for handling turbine fuels were advanced:

1. Provide enough tanks so that after delivery to a tank the fuel has sufficient time for particulate contaminants to fall to the bottom before fuel is drawn for use.

2. Draw fuel out of the storage tank via "floating suction" to avoid taking sediment.

3. Use a combination water separator and micronic filter, both when filling the storage tank and when drawing from it.

Fuel is consumed at such a tremendous rate in thirsty turbojets that continuous fuel management will become essential. Proposed at the Meeting was a means of computing optimum Mach number, altitude, and turbine engine pressure ratio for best range. All three are to be displayed on the instruments now registering these parameters.

Airborne Computers

Noting that the same flight parameters are used for cruise control and for navigation, fire control, and other purposes, other speakers recommended installation of one central airborne computer to handle all these needs.

With this degree of automation, one Meeting participant observed, the pilot becomes merely a monitor, and the distinction between "manned" aircraft and missiles becomes one that may be argued in future SAE sessions.

AT THE DINNER stewardesses from 12 airlines distributed corsages and boutonnieres. The girls and their flowers were from Air France, American Airlines, Braniff International Airways, Capital Airlines, Eastern Air Lines, KLM, Northeast Airlines, Northwest Airlines, Pan American World Airways, Trans-Canada Airlines, Trans World Airlines, and United Air Lines. Shown here receiving flowers from TWA stewardess are M. G. Beard, chairman of the dinner-dance, and Mrs. R. E. Johnson, wife of the SAE vice-president for the Aircraft Powerplant Activity.

SAE Vice-Presidents and Meetings Vice-Chairman Meet to Plan Technical Sessions for the Future

JACQUES ELSNER of Air France with Walker Gilmer, Air Transport Activity meetings vice-chairman who substituted for the Activity's Vice-President William Lawrence. Engineers from foreign airlines were specially invited to participate in the events of the Meeting.

R. E. JOHNSON, SAE Vice-President for the Aircraft Powerplant Activity; Muir Frey, Vice-President for Engineering Materials; and Eugene Manganiello; meetings vice-chairman for Aircraft Powerplants.

JOSEPH FAMME AND HARRISON HOLZAPFEL, vice-president and meetings vice-chairman, respectively of the SAE Aircraft Activity. Holzapfel is also general chairman of the SAE National Aeronautic Meeting to be held in Los Angeles in October. He appeared at the meeting of each of the three SAE aeronautic Activities to review plans for the fall Meeting.

570 Engineers Attend Aero Production Forum in

PRODUCTION engineers from all parts of the country gathered in New York to attend the SAE Aeronautic Production Forum held as part of the Aeronautic Meeting.

Subjects included industrial readiness, shortening the lead time cycle, manufacturing facilities for tomorrow, manufacturing research, developing human resources for production, and product reliability.

Sponsor of the 1957 Forum was G. M. Bunker, chairman of the board and president of Martin Co. The chairman of the Forum was G. T. Willey, vice-president, manufacturing, Martin Co.

Production Engineers Stress Designing for Reliability

MANUFACTURERS are beginning to realize that reliability must be designed into a product and be assured by quality control. Operators, of course, must stay within the product's operating specifications if they expect to obtain this built-in reliability.

This interesting information evolved at the panel session on *Product Reliability*.

Further discussion revealed that at least two new methods for insuring quality are being investigated. One is the application of X-rays (both straight and diffraction type) to determine or measure fatigue. The hope is for development of a method which will predict the failure of a part due to fatigue.

The application of nuclear radiation for detecting parts defects also appears to have great potential because of its adaptability and portable advantages. Using nuclear energy as a measuring or gaging tool also has distinct possibilities.

AERONAUTIC PRODUCTION FORUM LEADERS: (left to right) C. W. Goldbeck, J. S. Mason, and R. A. Winblad get some last minute tips from G. T. Willey (far right), forum chairman.

Engineers Predict Mach 10 At 150,000 ft within 10 Years

WITHIN 10 years, airplanes may be flying at speeds of Mach 10 at altitudes of about 150,000 ft. That's one prediction a panel session on *Manufacturing Facilities for Tomorrow* disclosed. New materials and manufacturing facilities will be needed to meet these demands.

Aluminum alloys will find their use limited in the future to the 300–400 F temperature range or speeds of Mach 2.2–2.4. Titanium will probably find use in the 600–1000 F range for speeds of Mach 3.5–4.5 at altitudes of 50,000–100,000 ft. The hard-type steels will take over in the 800–1200 F range —speeds of Mach 5–6 at altitudes of over 100,000 ft. And Inconel will probably be the wonder metal for the 1500–1700 F temperature range or speeds of Mach 10 at 150,000 ft.

New machining methods will have to be developed to produce the desired configurations for tomorrow's airplanes. Numerical tooling appears to have great potentials here. Because chip removal is costly with these expensive metals, disintegration types of machining may also find increased use. The hope, of course, is that forgings will be made to

New York

tolerances such that machining will be needed only as a finishing operation.

Industry Asks for a Realistic Defense Program

THE development of a realistic industrial defense program is sorely needed in the United States today, reported the panel session on *Industrial Readiness*. This program must provide for evacuation, survival, and continuity of management.

The present Industrial Defense Program, industry complains, is neither current, decisive, or even in agreement between the armed services.

Industry claims it has not been kept informed about the program nor given the needed financial assistance necessary to make such a program successful.

This situation emphasizes the need for greater cooperation among the armed services, public enlightenment, official participation, and a decision as to who will pay for this industrial readiness. At present, such funds do not exist.

New Methods and Techniques Help Shorten Lead Time

PRIME contractors are overlapping functions to reduce directly the lead-time cycle. Improved methods, techniques, and procedures are being used to shorten flow times.

Out of the discussion at the panel session on *Shortening the Lead-Time Cycle* came the news that prime contractors are using preplanning, the overlapping of functions, and the project-team

DISCUSSING CURRENT PRODUCTION PROBLEMS are G. T. Willey (left), Lt.-Gen. C. S. Irvine, Deputy Chief of Staff, Materiel, United States Air Force (center), and G. M. Bunker, chairman of the Board and president of Martin Co. Willey was chairman of the Aeronautic Production Forum, Irvine guest speaker at the forum luncheon, and Bunker sponsor of the forum and toastmaster at the luncheon.

"Our competition is closing in on us and it will take dedicated, creative thinking from every scientist, engineer, and production man in the country to keep the narrow lead we now enjoy," Lt.-Gen. C. S. Irvine, Deputy Chief of Staff, Materiel, USAF, told a luncheon meeting of the SAE Aeronautic Production Forum.

Irvine pointed out that in the future people must do, with tools and materials, what yesterday was considered impossible. This can only be achieved through improved use of engineering efforts. Emphasizing that engineering and design output must be integrated early in the development period, Irvine stated that aerodynamic and materials engineers, tool designers, and electronic specialists must maintain close and constant liaison with each other so that system compatibility and performance are assured from the outset.

In the past there has been a tendency to compartment these various engineering facets. This has provided maximum performance of separate components many times, but too often resulted in numerous modifications before the total weapon system could perform its function properly. . . . "we can no longer tolerate that type of effort nor the resulting time delays and cost over-runs."

Irvine praised the weapons system concept of procurement for its integration of engineering efforts and revealed that this concept is producing better equipment in far less time than under former operating arrangements.

Irvine urged scientific application of advanced electronic computers to expedite engineering solutions. Also suggested was maximum use of standardized components in the design of weapons systems.

"We are well aware," he said, "that it is very difficult for the vast number of engineering staffs to stay abreast of what is taking place in all the laboratories and drafting rooms across the nation. But through exchange of information as conducted by the Aircraft Industries Association and Armed Services Technical Information Agency, efforts are being made to increase the dissemination of new information. Full use of this information, whenever it can be applied, will save untold man-hours."

ENJOYING AN AMUSING STORY at the forum luncheon are J. E. Adams (left) and E. F. Gibian (right). Adams is vice-chairman for meetings of the Production Activity and Gibian is a former vice-president for Production Activity.

concept as means of shortening the lead-time cycle.

Numerical tooling is helping to shorten lead time, as are data reduction and simplified drawings. One of the thorns, however, to shorter cycles is the final test stage. Testing and its complexity is increasing. So the next major target for the prime contractors is the shortening of test procedures without sacrifice in reliability. Such a development would do much toward shortening the overall lead-time cycle.

Better Communications Needed by Researchers

POOR communications is slowing research work in this country, said a group of engineers at the panel session on *Manufacturing Research Development*. New techniques are being tried, however, to solve the problem.

Engineers in the laboratory are not getting the information necessary to make best use of their engineering resources. Reporting procedures are poor and sketchy and there is not enough interchange of research information between companies.

To remedy this situation, companies are getting away from departmentalizing too strongly in the hope that men working in closer cooperation with each other will result in better communications. In addition, information meetings are being held for the sole purpose of information exchange. Some companies are holding classes on the proper writing of reports.

The trend today is for the broad engineer who can be concerned with all phases of a problem. To do his job properly he must receive all phases of communication.

Aircrafts Offer Challenge to Engineers

AIRCRAFT manufacturers are attempting to "hold" engineering personnel by providing challenges commensurate with each engineer's ability. In addition, opportunities are being given to the hourly worker to advance into positions with technical responsibility.

These new trends in human relations were discussed at the panel session on *Developing Human Resources*.

Aircraft manufacturing companies are trying to reduce the relatively large turnover of engineers by constantly providing them with new challenges to their abilities. Surveys indicate that it is the lack of challenge and opportunity, rather than money, which causes the engineer to leave a company in most cases.

Rotation of jobs is being done to give the engineer a taste of the various facets of aircraft engineering. Training programs are provided for potential management men and further education at local universities (evening sessions) is encouraged. An atmosphere is being created which makes the engineer feel he is part of the job.

The shortage of engineers has amplified the need for advancing the hourly worker into more technical positions as he progresses in ability. He is offered training programs to further his abilities and is given status, both in money and title, as he progresses up the line. These incentives have created an atmosphere toward increased productivity on the part of the worker.

Aero Production Forum Leaders

J. D. Wethe
manager, marketing production
engineering department, General Electric Co.

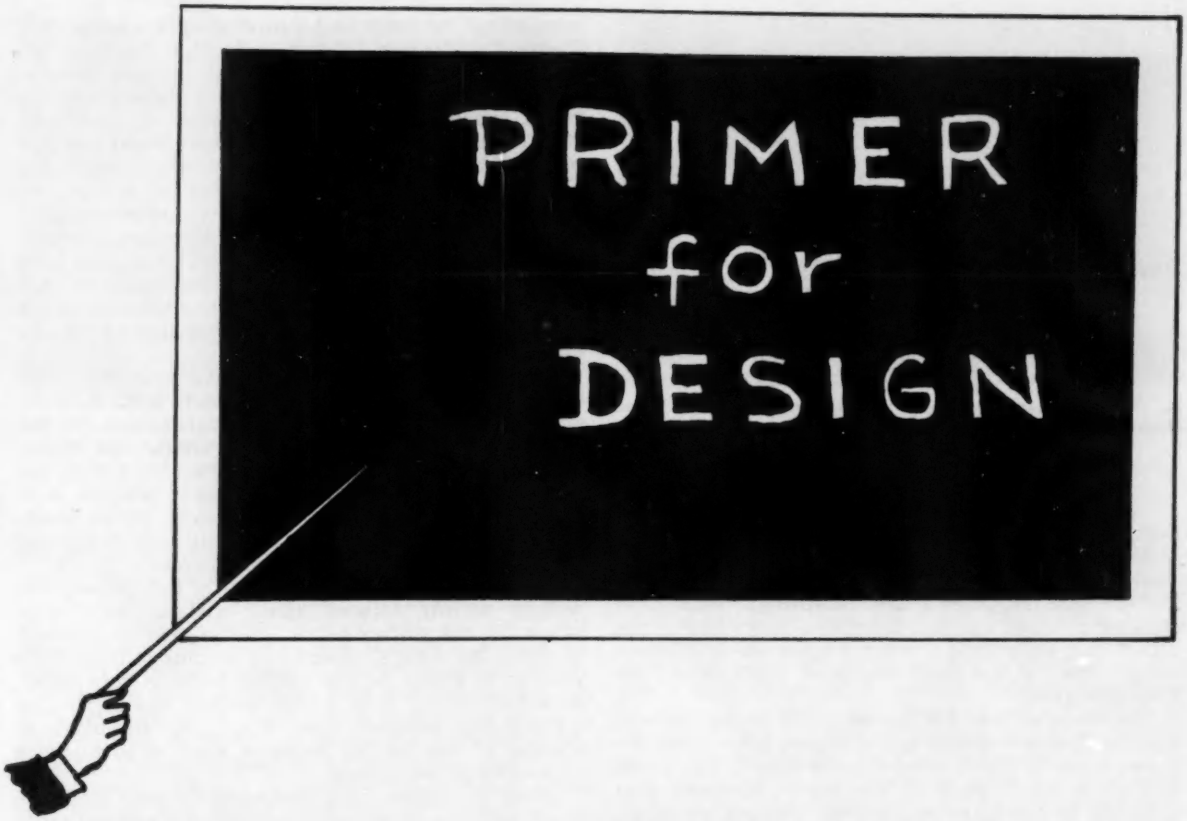
T. F. Nagey
manager
Nuclear Division, Martin Co.

J. S. Mason
director, manufacturing
Martin-Orlando

C. W. Goldbeck
assistant staff director
Industrial Engineering, Thompson Products, Inc.

R. A. Winblad
chief engineer
Process Machinery Division
Cincinnati Milling Machine Co.

W. N. Phillips
sales administration
sales engineering department
Aircraft Armaments, Inc.



FOR THOSE who want to "brush up" on their design knowledge here is an elementary treatment of the basics—and how to make use of them in designing for strength.

Based on paper by **R. C. Barnes,** Caterpillar Tractor Co.

WHEN we talk about designing for strength, the first concept that comes to mind is that of stress. STRESS is defined as the load on a part divided by the area of the cross-section which supports the load. There are two kinds of stress: static and dynamic. STATIC STRESS means that the load is applied once and does not change with time. Good examples of this are the Sphinx and pyramids of old Egypt.

When we have static stresses there are two kinds of failures that can occur: a brittle type, and a yielding type (bending). Often, of course, the two are combined. That is, the part yields first and then breaks. The common rubber balloon is a good example here.

The rules that apply for static stresses are pretty well understood. For example, with steel we have a simple straight line relationship between the brinell hardness of the steel and its strength. This doesn't concern us too much, however, because static stresses in machinery are more or less unusual and are comparatively easy to calculate or evaluate by testing.

But DYNAMIC STRESSES are a different story. We encounter these in almost every kind of machinery made, and they're important because of something known as fatigue. FATIGUE means that a part can break in two at a load much lower, perhaps about half of that required to break it under static stress. A fatigue failure is always of the brittle type.

For steel the fatigue strength follows a simple pattern known as the S-N curve (Fig. 1). The horizontal scale represents the number of cycles or

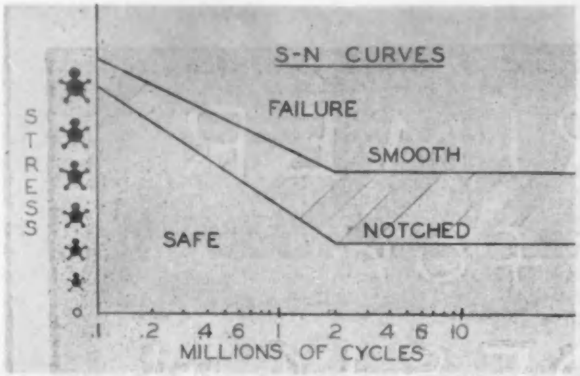


Fig. 1—The S-N curve provides a simple method of determining the fatigue strength of steel for any load frequency.

number of times the load is applied. The vertical scales indicates the stress on the part. The area above the line represents a failure and the area below the line indicates a safe condition. This curve shows that when the load is applied only a few times, a part can withstand a much higher stress without failure than if the load is applied more often, say 1,000,000 times.

The slope of the S-N curve levels off somewhere around 2,000,000 cycles, and if a part lasts 10,000,000 cycles there is a very good chance that it will never fail under load. Note on the curve, however, that a notch in the part reduces its fatigue strength. This is because of a stress concentration at the notch. To visualize this condition, assume that stress wants to flow in straight lines like the water in a stream. If a notch is put in the way, the flow lines have to bend around it. This concentrates the stress about the notch. How much this condition reduces fatigue strength depends on the sharpness of the notch and also on the material.

Most fatigue tests are made with the load fully reversed which, in machinery, is usually not the case. To determine the effect of the steady load component we refer to a simple diagram called the Goodman diagram (Fig. 2). In this diagram the fatigue limit is plotted plus and minus from the zero line at the left. At some arbitrary distance to the right, the ultimate strength is plotted, and from this point lines are drawn to the zero point and the plus and minus limits of the fatigue strength. Then, since yielding is considered as failure, we lop off the top of this curve at the yield strength and trim off the bottom to make the area symmetrical about the mean stress line. The shaded area on the diagram then represents the range of safe loading. For steel, in most cases, this area has a tendency to bulge somewhat as indicated by the dotted line.

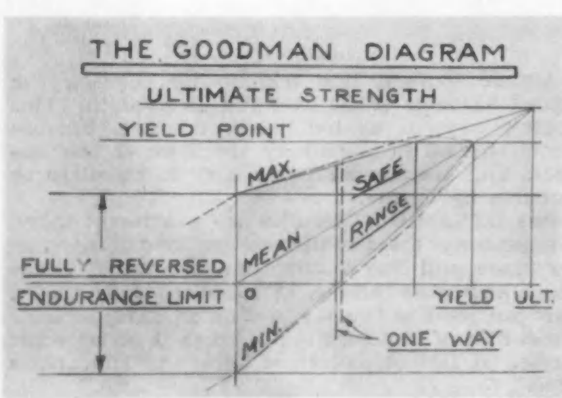


Fig. 2—The Goodman diagram indicates the effect of the steady load component on a part. The shaded area represents the range of safe loading.

Now let's suppose you have built a machine. You have calculated all the stresses, made them safe according to what has been said so far, and yet the machine breaks the first time it is tried. The reason for failure is probably VIBRATION. To better understand what happens, visualize a weight supported by a rubber band, the end of which is attached to an arm capable of being moved up and down at an infinite number of speeds.

If the arm moves up and down very slowly the weight merely follows along without any extra stress on the rubber band. If the arm moves very rapidly, the weight practically stands still and the change in stress on the rubber band is very small. However, if the arm moves at just the right frequency (the resonant frequency), the amplitude of motion of the weight becomes very large and the rubber band will break.

Much the same thing happened to your machine, the frequency of vibration reaching a critical point where the forces were great enough to cause damage.

Now let's visualize a TORSIONAL VARIATION of this same phenomenon. Imagine three flywheels connected by flexible shafting. If we turn one end of this system very slowly the other end follows with very little twist of the shaft. If we turn rapidly, very little motion is transmitted to the other flywheels. But, again, if we find the right frequency, the amplitude at the far flywheel becomes very large, indicating the resonant condition.

Designing for Strength

Now that some of the basics of design have been covered, let's look at some of the methods available for increasing the strength of the design.

First, however, we must check the vibration to which the design will be subjected. Because if we don't know the vibration we don't know the stress, and if we don't know the stress we obviously cannot know how strong to make the part. There are instruments on the market and skilled people available to make this analysis.

If the analysis reveals a weak spot, the thing to do is to add material. A heavier part is a stronger part. There are times, however, when this is impossible, either because the space isn't available or because we can't afford the additional weight.

If we can't add material, we can always try a harder material. Fig. 3 shows a number of strength curves for steel. Note that in almost all cases the fatigue strength of the material increases with hardness. (The only exception here is the rough

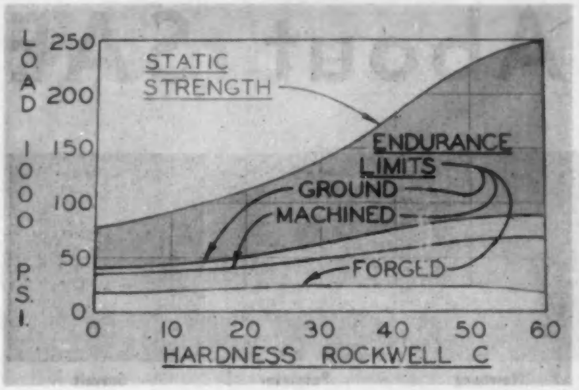


Fig. 3—Fatigue strength increases as the hardness of a material increases. Also, the smoother the finish, the greater the fatigue strength.

Fig. 4—Stress concentrations caused by fretting made this part fail.

forged surface which becomes weaker at hardnesses above Rockwell C45.)

The same curve shows another way of strengthening a design. Notice that for any hardness, the smoothest surface finish gives fatigue strengths almost three times greater than the roughest finish. This is why the connecting rods and crankshafts in aircraft engines are machined and polished all over, and sometimes this may make the difference between a successful part and failure in a design.

Somewhat related to surface finish are notches and fillets. A large, smooth fillet always gives greater strength than a sharp notch. In fact, a sharp notch may reduce the strength of a part in fatigue by as much as two-thirds.

Case-Hardening Provides Double Benefit

Case-hardening increases the strength of a part by taking advantage of residual stresses. This condition results in a double benefit—increased strength at the surface because of the harder material, and increased fatigue strength due to compressive residual stresses in the carburized layer.

Rolling the surface of a part provides a similar increase in strength. We all know that baking dough increases in area when it is rolled. Well the surface of a steel part tries to do the same, but since it is fastened to the material beneath is unable to do so and is left in a state of compressive residual stress. This improves its fatigue strength. In addition, rolling work-hardens the surface, which further increases the fatigue strength.

Shotpeening the surface of a part gives exactly the same results as rolling. Which method to use is strictly an economic choice—that is, with the exception of parts whose irregular shapes prohibit rolling. At times, rolling or peening as much as doubles the fatigue strength of a part.

One additional way to strengthen a design is by avoiding such stress concentrators as fretting and press fits.

The shaft shown in Fig. 4 has a sharp cornered keyway which logically would be expected to be the source of any fatigue failure. However, the wavy lines on this part show that failure actually started on a perfectly smooth round surface. The dark area indicates fretting, and since failure occurred at this point, we have proof that the fretting was a greater stress concentrator than the sharp cornered keyway. When there is a possibility of two parts rubbing together, we must either clamp them together so tightly that fretting cannot occur, or else keep the stress low enough to allow for the stress concentration that will be present.

A press fit is also a severe stress concentrator. Note in Fig. 5 that the shaft acts as if it were made of rubber with the part pressed over it squeezing it down in size and causing a physical notch at the edge of the pressing part. In this case the press fit is almost as bad a concentrator as the filleted shoulder shown at the right end of the shaft.

(Paper, "Designing for Strength," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers).

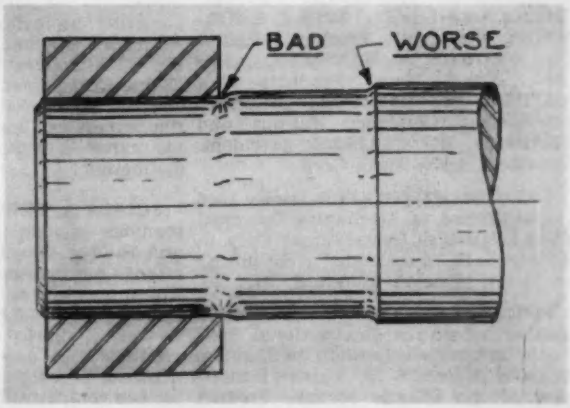


Fig. 5—Press fits are another stress concentrator which reduce the fatigue strength of a part.

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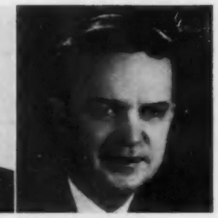
Walker


Newberg


Potgieter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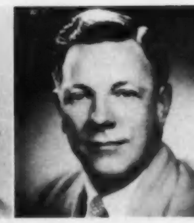
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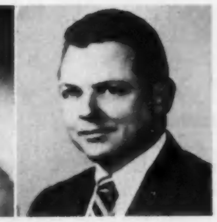

Conner


Burke


Braendel


Lutz


Cockrem

EDWIN H. WALKER has been elected president and general manager of General Motors of Canada, Ltd. Walker first reported to McKinnon Industries, GM subsidiary, in 1929 while a student at GM Institute at Flint. He became a full-time employee and served as an inspector, foreman of inspection, in Delco operations, and later superintendent. For two years Walker was assistant to the general manager and in 1953 was named president and general manager of McKinnon.

He now serves as SAE vice-chairman of SAE Canadian Section.

WILLIAM A. WECKER, previously president of General Motors of Canada, Ltd., is retiring after 21 years of service, nearly 12 of which he served as head of GM of Canada. Before joining GM in 1936, Wecker was president and general manager of Hayes Wheels and Forgings, Ltd., Chatam, Ont., and also was president and general manager of McKinnon from 1941 to 1943.

Wecker is a past-chairman of SAE Canadian Section.

E. JOHN BARBEAU has been elected president and general manager of McKinnon Industries, Ltd., to succeed Walker. Barbeau joined McKinnon in 1934 as a clerk and subsequently was made superintendent of forge operations; foundry assistant general superintendent; superintendent of the foundry. In 1954 he was named manufacturing manager at McKinnon's Grantham Township plant and factory manager in 1956.

WILLIAM C. NEWBERG, group vice-president—automotive, Chrysler Corp., has accepted the chairmanship of the Automotive Division of the National Fund for Medical Education. In accepting the appointment, Newberg stated that his committee would seek to enlist the support of all automotive companies.

Serving with Newberg are the following SAE members: **COL. WILLARD F. ROCKWELL**, chairman, Rockwell Spring and Axle Co.; **S. D. DEN UYL**, president, Bohn Aluminum and Brass Corp.; **JAMES P. FALVEY**, president, Electric Auto-Lite Co.; **ROY C. FRUEHAUF**, president, Fruehauf Trailer Co.; **GEORGE A. HANSMAN**, president, Triad Metal Products Co.; **ARTHUR W. KIMBELL**, president, United-Carr Fastener Corp.; and **CHARLES W. PERELLE**, president, American Bosch Arma Corp.

FRED M. POTGIETER, since 1946 vice-president of Mechanics Universal Joint Division of Borg-Warner Corp. in Rockford, Ill., has opened a consulting engineers office in Rockford, Ill.

PHILIP C. SERVAIS, was a featured speaker before the International Synthetic Rubber Symposium in London, England, March 26–28. Servais is manager of the Silastic section, Product Engineering Laboratories at Dow Corning Corp.

SAE Past-President A. T. COLWELL, vice-president of Thompson Products, Inc., received a distinguished service award last month from the Cleveland Technical Societies Council. Presented for Colwell's having contributed "greatly to the advancement of the engineering profession over the years," the award was made on the occasion of the CTSC's eleventh annual banquet. Noting Colwell's many contributions to engineering, the citation continues "on the annals of his chosen profession, his name is written large and with distinction."

JULIUS A. LUCAS has been named manager of field sales, Goodyear Tire and Rubber Co. He will have charge of customer contact in Milwaukee and Chicago as well as Detroit.

ROBERT C. GANNETT, previously in overall charge of automotive foam products and floor mat sales, is now manager of automotive trim materials for the company.

Both Lucas and Gannett, in 1945, joined Goodyear's manufacturers' sales operations from other areas of the company.

JOSEPH PALSULICH will represent Cleveland Graphite Bronze Co., division of Clevite Corp., as west coast sales manager. Since September he has represented Cleveland Graphite Bronze in the four-state area of Washington, Oregon, California, and Arizona.

H. PELPHREY, formerly chief research engineer of Michigan Tool Co., Detroit, has been appointed director of engineering research. He joined the company in 1929 and has served as chief research engineer since 1939.

BEN W. BADENCOCH has been named general manager of the new Aero Hydraulics Division, Vickers Inc. Previously he was manager of Aircraft Products Sales, Vickers Inc.

M. A. HAYDEN, formerly general manager of the Waterbury Tool Division of Vickers Inc., Waterbury, Conn.,

Members


Colwell


Lucas


Gannett


Palsulich


Fish

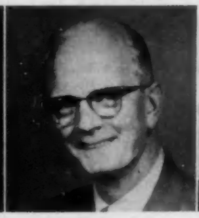

Weber


Cuthbert


Lucia


Wernig


Cotter


McVeigh


Gamble

has been made general manager of the recently created Machinery Hydraulics Division.

W. F. DRIVER has been appointed general sales manager of the Machinery Hydraulics Division. Prior to this appointment he was manager, Industrial Products Sales, Vickers Inc.

RAY CONNER will head the new Mobile Hydraulics Division as general manager, changing from the post of general manager of the Automotive Division of Vickers Inc.

LEON H. FISH, formerly central district manager for Solar Aircraft Co., has been named to a newly created executive position as assistant to the president of Acme Precision Products, Inc., Dayton, Ohio.

BERNARD R. WEBER has been elected vice-president for engineering and manufacturing, the Fulton Co., West Allis, Wis. He joined Fulton in 1940 as chemical engineer and advanced progressively to chief engineer. In 1954 he was elected a director of the company.

HARRY CUTHBERT has recently been appointed to serve as installations engineer for industrial engines at Avco Lycoming, a division of the Avco Mfg. Corp. Previously Cuthbert was with Douglas Aircraft, Inc., where he served as powerplant designer.

CARROLL J. LUCIA is now development engineer, advanced design section, Automotive Transmission Division, Ford Motor Co. Formerly he was manager, driveline section, Packard Engineering, Packard Division, Studebaker-Packard Corp. In his new position, in addition to product development and testing, he will handle design of fluid devices and control systems.

Lucia is a member of the SAE Hydrodynamic Drive and Transmission Committee.

WILLIAM J. BURKE, JR., sales manager of the Modine Mfg. Co.'s Automotive Division since 1930, has been named manager of market planning. Burke will be working with new product and market investigation.

In 1929, Burke joined the Modine organization as eastern sales manager of the company's Heating and Air Conditioning Division.

HELMUTH G. BRAENDEL, previously director of engineering and production for Wilkening Mfg. Co., has been named vice-president in charge of engineering for the company.

Braendel worked with Chrysler Corp. from 1935 to 1942 when he joined Continental Motors, Detroit, as assistant and subsequently chief development engineer on tank engines. He has been with Wilkening since 1945.

An active member of SAE, he is a member of the SAE Diesel Engine Activity Committee.

JOHN O. LUTZ, formerly assistant chief engineer, has been made chief engineer at Wilkening. In 1954, Lutz came to Wilkening from Baldwin-Lima-Hamilton Corp. where he served for about eight years as project engineer in the design and development of diesel engines.

THOMAS F. COCKREM has been assigned from assistant manager to manager of the highway transportation department for Goodyear Tire and Rubber Co.

In 1937, Cockrem joined Goodyear, working on the production and engineering training squadrons and serving as a draftsman and field contact representative in the Research and Development Division. He joined the highway transportation department in 1938, holding positions of district and division field manager before appointment of assistant manager in 1949.

JAMES H. WERNIG has been appointed to the newly created position of general director of product engineering, process development, production engineering and related activities at Fisher Body Division of General Motors Corp.

BART COTTER, assistant chief engineer, has been named to succeed Wernig as chief engineer.

ROBERT M. McVEIGH, senior engineer-in-charge, product engineering department, takes over the former responsibility of Cotter as assistant chief engineer.

D. EDWIN GAMBLE has retired from chairmanship of Borg & Beck Division of Borg-Warner Corp. He is also retiring from the board of directors of Borg-Warner Corp. Prior to these positions, from 1919 to 1929, he was chief engineer of Borg & Beck and subsequently president and general manager until 1954. He also served as chairman of the board, 1955 to 1956.

Gamble has been a member of SAE since 1912 and has served on the Production, and Passenger Car Activity Committees and also on a transmission technical committee. He is past-chairman of SAE Chicago Section.


Firestone


Johnson


Redding


Drader


Gadebusch


Delaney


Esty


Beringer

RAYMOND C. FIRESTONE has been named president of the Firestone Tire and Rubber Co. He joined the firm in 1933 and has served in numerous production sales and research posts before becoming executive vice-president in 1954

JAMES E. TRAINER succeeds Firestone as executive vice-president.

LLOYD EDWARD JOHNSON, previously staff engineer—research department, Caterpillar Tractor Co., has been made assistant director of research for the company. He now directs the advanced powerplants research program.

Johnson has been active on the Diesel Engine Nomenclature Subcommittee of SAE Diesel Engine Activity.

JAMES D. REDDING has been appointed general manager of the sales and service department at the Westinghouse Electric Corp.'s Aviation Gas Turbine Division. Redding, former manager of the headquarters sales department of the division, was given the temporary appointment as acting manager of the sales and service department on Jan. 1.

Redding has served with SAE technical committees, including manager of the Aeronautics Department from 1947 to 1949. He was responsible for SAE's efforts in a comprehensive standardization program in the field of aircraft engines and various other important aircraft parts. In 1955, Redding was SAE vice-president representing Aircraft Activity.

J. C. DRADER, present vice-president of Michigan Tool Co., Detroit, has been named vice-president, research, a new post created by the company's expanding work in the gear development field.

Drader joined Michigan Tool Co. in 1916 as a lathe hand and was made shop foreman in 1917, general foreman in 1921, and chief engineer in 1924. From this position he was appointed general manager and elected vice-president in 1941.

HANS M. GADEBUSCH is now a special projects engineer for the Truck and Coach Division, General Motors Corp. He joined GM Research as a designer in 1925, and, prior to his new assignment, was a liaison engineer at the GM Technical Center.

EUGENE B. DELANEY has been named branch manager of the newly-merged sales offices of Purolator Products, Inc., Rahway, N. J., and its wholly owned subsidiary, Industrial Wire Cloth Products Corp., Wayne, Mich. Delaney was associated with Ford Motor Co. from 1934 to 1947, working on their turbo supercharger and ram jet engine projects. In 1947 he joined Purolator as Michigan and Ohio sales representative and in 1955 was appointed Detroit branch manager.

F. BURROWS ESTY, chief engineer, has been appointed vice-president of the Wisconsin Motor Corp. Esty has been with the company since 1948, joining as assistant chief engineer and becoming chief engineer in 1955.

Esty is chairman of SAE Milwaukee Section's Program committee.

GEORGE E. BERINGER has been appointed general manager of the aircraft products section of the Bendix Products Division, Bendix Aviation Corp. in South Bend, Ind. He has been serving as assistant general manager since 1956.

Beringer joined Bendix in 1936 as a project engineer, and in 1946 was made chief engineer of aircraft landing gear department. He was named assistant factory manager in 1950, and factory manager in 1951.

Continued on page 110

Obituaries

LEO L. WILLIAMS

Leo L. Williams, engineering consultant and member of SAE since 1918, died on Oct. 4, 1956.

Williams was born in 1889 in Anderson, Ind. and began in industry in 1907 as an engineer of the original Lambert friction drive commercial and passenger bus. Three years later he joined the Peerless Motor Car Co. as chassis and motor engineer.

From 1911 to 1917 he was body engineer and manager for commercial and passenger cars at Peerless. In 1917 he organized and served as works manager for Lang Body Co.

Williams joined E. J. Thompson Co. in 1921 as works manager, converting passenger car and body business into bus business. Following this, he was plant engineer, body designer and production engineer with Chandler-Cleveland Motors Corp.

From 1929 to 1932 he was Cleveland resident body engineer, Hupp Motor Car Co. and later became designer, production engineer, and plant layout engineer with Union City Body Co.

Williams spent 1936 revamping and changing over the Superior Bus Co. plant in Lima, Ohio, and then returned to the Union City Body Co.

From 1945 to 1950, Williams managed the Window Division of Visionator, Inc., Chicago, making bus windows for General Motors Corp. Truck and Bus, Pontiac, Mich. Since 1950 Williams had owned and operated the Sandusky Nut Co., Inc., making special threaded nuts and studs.

In his 38 years of SAE membership, Williams was active both on the National and Sectional levels. He was vice-president representing Body Activity in 1937 and served, from 1943 to 1948, on the Body Activity Committee.

Williams seldom missed a Cleveland Section meeting and it was he who had the original idea in 1925 to start a Section publication. The result was the first Section publication, the Cleveland Section Junior Journal.

Continued on page 123

SECTIONS

MAY 1957

Governing Board Members To Meet for Round Table Talks

Discussions on a combination of policy, innovations, and development of ideas for SAE activities on the Sectional level will be the keynote for the first Section Governing Board Round Table luncheon which is to be held on June 5 at the SAE Summer Meeting in Atlantic City.

Purpose of the round table talks is to serve as a sounding-board for Section Governing Board members' thoughts on Section operations.

Leading the talks will be a four-man panel consisting of the chairmen of the four administrative committees which handle the membership affairs of the Society—Sections Committee, Membership Committee, Placement Committee, and Student Committee, whose chairmen are respectively **T. R. Thoren, F. B. Lary, L. O. Ray,** and **L. L. Otto.**

So. California

F. E. Arhur, Field Editor

Check List Found Boon to Committee Chairmen

"First time I ever knew what I should do" was a typical response to the newly inaugurated idea of a check list for the use of the Section Activity chairmen.

The concept was originated by the Section's Governing Board Secretary **Robert Strasser** as a tool to be used by the Activity chairman in the coordination of all those participating in the meeting.

The Secretary prepares the check sheet with "due dates" for each meeting scheduled, showing when and what information is required by the Secretary and other activities for printing of notices, for SAE Journal notification, and for meeting preparations.

It works like this: when a specific date has been set for a meeting, the Secretary makes out the check sheet and sends it to the Activity chairman —the man who is responsible for making all arrangements for the specific meeting involved.

The check sheet formula includes such standard items as: name of the Activity chairman who is in charge of the meeting; the Activity sponsoring the meeting and the type of meeting such as dinner, panel, seminar or symposium; and time and location of the meeting.

It also covers such points as: picture of the speaker if it is needed for the meeting notice; information needed for notice in SAE Journal and its deadline; data to be secured for the meeting notice and the date it is due; and the notification to the field editor of the availability of the speaker's talk or paper.

Also itemized are such details as: equipment needed for meeting; head table list which includes the names, titles, and company affiliations; and names of guests to be met.

A final note on the check sheet explains that the indicated dates are considered the latest ones in which the job can be done adequately while earlier receipt of data would be helpful to all persons involved.

ALBERTA

L. A. Dulmadge, Field Editor

Charles Harrison, deputy fire chief, Calgary Fire Department, addressed the Alberta Group at the March 25 meeting. The talk explained all phases of fire-fighting and equipment in use from the stone age to the present.

Philadelphia

E. V. Henc, Field Editor

"Inventions and Patents" was the paper presented by **Arthur S. Seidel,** Philadelphia and New York patent attorney at Philadelphia Section's March meeting. Discussion centered around process methods in Washington and the pitfalls of uninitiated inventors in securing patents.

Section Meetings

BRITISH COLUMBIA

May 21 . . . **J. H. Booth,** chief engineer, Michigan Division, Thompson Products, Inc.—"Hydro Truck Retarders." Hotel Georgia. Dinner 7:00 p.m. Meeting 8:00 p.m.

June 3 . . . Annual Meeting, Election of Officers. A film on "Wheels to the Antarctic" will be presented.

BUFFALO

May 15 . . . Topic: "Sports Cars." Buffalo Trap & Field Club. Dinner 7:00 p.m. Meeting 8:30 p.m. Display Sports Cars & Antique Cars at 5:00 p.m.

CANADIAN

May 30 . . . Kitchener Meeting. Westmount Golf and Country Club. Dinner 6:30 p.m. SAE Canadian Section members only.

CHICAGO

May 14 . . . **H. B. Osborn, Jr.,** technical director, Tocco Division, Ohio Crankshaft Co., Cleveland.—"A Good Look at Automation." Hotel Knickerbocker, Chicago. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Features: Social Half-Hour 6:15 p.m. to 6:45 p.m.

May 24 . . . Ladies Night. South Shore Country Club.

CLEVELAND

May 13 . . . **Lt. Col. G. M. Anderson,** Atomic Energy Commission. —"Radioisotopes for Power." Manger Hotel. Dinner 6:30 p.m. Meeting 7:45 p.m.

DETROIT

May 24 . . . Michigan Proving Ground, Ford Motor Co., Romeo, Michigan. Tour. Speaker: **Andrew A. Kucher,** director, Engineering Staff, Ford. Toastmaster: **John A. C. Warner,** secretary and general manager, Society of Automotive Engineers, Inc.

INDIANA

May 16 . . . **Mr. Strope,** captain, Mercury Racing Team, Mercury Division, Ford Motor Co.—"Stock Car Racing." Athenaeum, 401 E. Michigan, Indianapolis. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Features: Film on Speed Trials at Daytona Beach, Fla.

METROPOLITAN

May 17 . . . Section Dinner Dance. New York Athletic Club, Travers Island, Pelham, N. Y. $8.00 per person. Cocktail Hour (Sponsored) 6:30 p.m. Dinner 7:30 p.m. Dancing 8:30 p.m.

May 23 . . . Long Island Aeronautic Activity Meeting. **W. H. Sharp,** engineering metallurgist, Pratt Whitney.—"Use of Titanium in the J-57." Bethpage Country Club, Bethpage, L.I. Meeting 7:45 p.m.

MONTREAL

May 28 . . . **A. F. Underwood,** General Motors Corp.—"Free Piston Engines."

NEW ENGLAND

June 3 . . . Annual Outing. Woodland Golf Club Auburndale. Dinner 6:00 p.m.

NORTHWEST

May 17 . . . **J. H. Booth,** chief engineer, Thompson Products, Inc., Michigan Division.—"Hydro Truck Retarders." Stewart Hotel. Dinner 7:00 p.m. Meeting 8:00 p.m.

PITTSBURGH

May 16 . . . **William St. Germain,** technical representative, Boeing Airplane Co., Industrial Products Division, Seattle, Washington.—"Application Experience with and Future Potentialities of Small Gas Turbines." Wanango Country Club. Dinner 6:30 p.m. Meeting 8:00 p.m. Special Features: Spring Outing.

ST. LOUIS

May 14 . . . **Captain D. L. Steele,** Federal Barge Lines.—"River Transportation and Maintenance." Congress Hotel. Dinner 7:00 p.m. Meeting 7:45 p.m.

SOUTHERN CALIFORNIA

May 13 . . . Aircraft Dinner Meeting. (Annual Mac Short Memorial Award).

SOUTHERN NEW ENGLAND

May 17 . . . Annual Social Event. Rockledge Country Club, West Hartford, Connecticut. Dinner 7:00 p.m.

WILLIAMSPORT

June 7 . . . Annual Ladies Night. Dinner-Dance. Williamsport Country Club. Dinner 7:00 p.m.

Metropolitan

H. H. Wakeland, Field Editor

SAE Student Branch members from the City College of New York were treated to a talk on the new developments in aerodynamics by **Vincent Tizzio**, design specialist of the Republic Aviation Corp. on March 21.

Interest in the field of aerodynamics was demonstrated by the large turnout among both students and faculty.

ST. LOUIS

F. H. Myers, Jr., Field Editor

Parks College of Aeronautical Technology of St. Louis University, with a total of 1182 points as opposed to 1174 points tallied by Missouri School of Mines, was the winner of Saint Louis Section's annual student paper contest which was held in March.

As is traditional, the winning team was presented the St. Louis Section Student Award Banner (shown above) which remains a possession of the victorious school until the following year's contest.

Competition for individual speaker's top-spot honors resulted in a draw between Bruce Lewis of Missouri School of Mines and William Bracken from Parks College. Patrick DeLuca also from Parks shared the spotlight as third prize winner.

From Student Cameras

1. Principal speaker at the joint meeting of the General Motors Institute and Michigan State University SAE Student Branches was **Prof. Louis Otto,** SAE Student Committee chairman.

2. Students from the General Motors Institute and University of Michigan relax at the joint meeting held on March 10 at the Institute.

3. Speaker at the Jan. 22 meeting of Chrysler Institute of Engineering SAE Student Branch was **Carl W. Cenzer** (left), executive body engineer, American Motors Corp. Standing with Cenzer are **R. W. Rockefeller** (center), assistant director, Chrysler Institute of Engineering; and **William Salisbury** (right) Chrysler Institute SAE Student Branch chairman.

From Section Cameras

1. Guest speaker at **San Diego Section's** May 6 meeting was **R. T. Jackson,** sales engineer, Manufacturer's Division, Perfect Circle Corp.

Jackson opened the meeting by showing a color sound film entitled "500 Miles To Go" and then presented a talk dealing with the powerplants and structural features of cars which finished in the money in the 1956 Indianapolis Memorial Day Race.

2. Mid-Michigan Section Program Chairman **D. P. Marquis** (left) introduces speakers for the Feb. 4 meeting **Darrell Romick,** topic for the evening was "The Dawn of the Age of Space Flight."

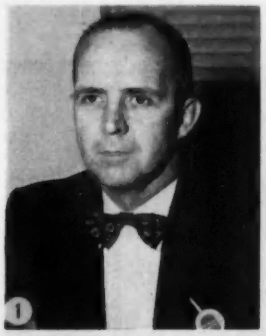
3. As a feature event of the meeting **Martin Caserio** (right), Section vice-chairman, presented certificates of appreciation for over 25 years' active membership in SAE to **John Heiss** (left), and **Ralph Duckworth** (center).

4. Turbo-prop engine tests was the subject discussed by **Major William R. Stantan** (standing) at the **South Texas Group's** February meeting. Major Stantan holds numerous flight records in turboprop powered aircraft.

5. Seated at the speakers' table at the **South Texas Group** Annual Student Meeting are left to right: **Leo Dubinsky,** Group treasurer; **Dr. Harold Vatborg,** president, Southwest Research Institute; **Norman C. Penfold,** vice-president, Southwest Research Institute; **Dr. C. G. A. Rosen,** consulting engineer, Caterpillar Tractor Co. and SAE past-president, who spoke on "The Application of Gas Turbines to Power Systems"; and **Ludwig Motulsky,** Group chairman.

6. **R. E. Fisher** (right), Mid-Michigan Program chairman at the March 11 meeting is shown with guest speaker **R. C. Allen** director of mechanical engineering, Allis-Chalmers Mfg. Co. who discussed "Power from the Atom."

From Section Cameras



1. Featured speaker at the March 19 meeting of the **Washington Section** was **Robert W. Cuthill**, deputy director, Industrial Operations Division, Army Ballistic Missile Agency.

Cuthill addressed the audience on the program of the Army Ballistic Missile Agency and its relations to automotive engineering.

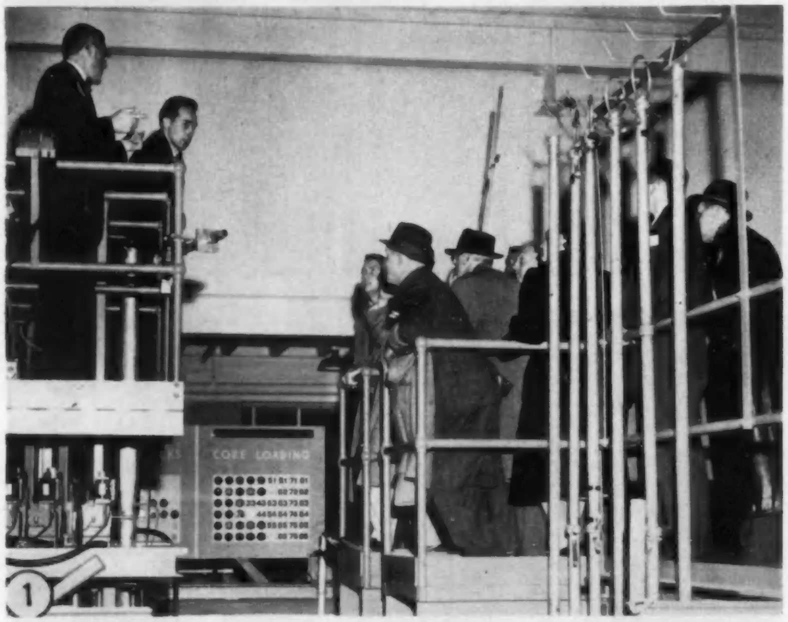
2. **Western Michigan Section** vice-chairman **LaVern W. Kibbey** introduces guest speaker **Paul T. Vickers**, supervisor, heat transfer section, General Motors Corp. research staff, who spoke on "Gas Turbine Engines" at the Section's March 5 meeting.

3. A near capacity crowd heard **Alexander Hossack** (center), manager, hydro-mechanical department, Simmonds Aerocessories, Inc. speak on "Fuel Injection System for Gasoline Engines" at the April 2 meeting of **Northern California Section's South Bay Division.** At left is Northern California Section Chairman **Elvin Lien** and at right is South Bay Division Program Chairman **Vincent Gilbert.**

4. **Montreal Section Chairman R. A. Harvey** (right) presents **SAE President W. Paul Eddy** (left) with two wooden Canadian figurines as a momento of President Eddy's visit to Montreal.

5. **SAE President W. Paul Eddy** (center) had occasion to pose for this Journal photo with the **Montreal Section's** Governing Board at the Section's March 19 meeting.

From Section Cameras



1. Featured event of the Columbus meeting of the **Dayton Section,** held on March 19, was a tour of part of the Nuclear Research Center near Columbus, Ohio, of Battelle Institute.

Standing on the left bridge are **Dr. H. R. Nelson** (left) manager of Battelle's physics research, and **Joel W. Chastain** (right), who is in charge of the reactor physics research. The Battelle officials explained the one megawatt reactor and answered questions for those present.

2. **C. H. Nystrom** (center), chief engineer, fuel injection section, American Bosch Division, American Bosch Arma Corp., explains "Fuel Injections for Automobiles" at **Mohawk-Hudson Section's** March 12 meeting to listeners from left to right: **P. E. Kezer,** Section vice-chairman; **Ralph Hooker,** Section past-chairman; **Paul Hillman,** president, Fort Edward Express Co.; and **M. J. Severino,** Publicity chairman.

3. Approximately 1000 members and guests were on hand at **Detroit Section's** meeting of March 25 when a tour of Pontiac Motor Division, General Motors Corp. was held.

Seated at the speakers' table from left to right are: **W. D. Angst,** Detroit Section Production Activity assistant vice-chairman; **F. L. Bird,** operating manager, DeSoto Division, Chrysler Corp.; **G. A. Delaney,** SAE president in 1956; **D. J. Davis,** vice-president, manufacturing, Ford Motor Co.; **T. E. Seavey,** master mechanic, Pontiac Motor Division, General Motors Corp., who traced the development of an aluminum coating system for engine valve heads; toastmaster for the dinner, **E. M. Estes,** chief engineer, Pontiac Motor Division, General Motors Corp.; **C. C. Dybvig,** Detroit Section Chairman; **B. E. Starr,** general manufacturing manager, Pontiac Motor Division, who gave a description of Pontiac's layout; **J. J. Cronin,** vice-president, manufacturing staff, General Motors Corp.; **C. J. Demrick,** vice-president in charge of manufacturing, Plymouth Division, Chrysler Corp.; **W. D. Singleton,** general manufacturing manager, Lincoln Division, Ford Motor Co.; **G. R. Fitzgerald,** Detroit Section Production Activity vice-chairman.

From Section Cameras

1. Jet fuel experts took a look at the past and the future at **Mid-Continent Section's** March 1 meeting.

Examining the 1912 pusher plane built by **W. D. Parker** (seated), manager of aviation sales, Phillips Petroleum Co. are from left to right: **M. C. Hardin,** chief of Fuels, Lubricants, and Basic Combustion Division, Allison Division, General Motors Corp.; **M. G. Beard,** assistant vice-president for equipment research, American Airlines, Inc.; and **R. C. Alden,** chairman of the Phillips Research Planning Board.

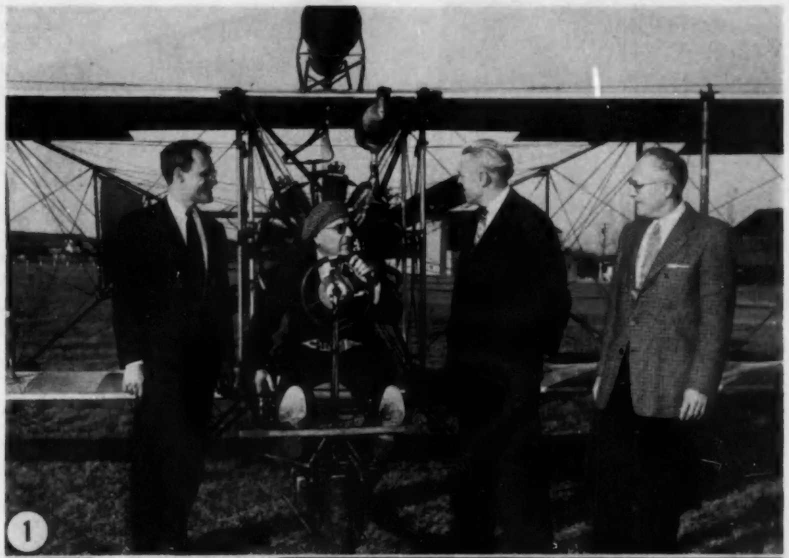
The open meeting was devoted to discussion of requirements of commercial jet fuels by the three speakers, who represented the aircraft engine, air transport, and petroleum industries.

2. "Putting Engine Power to Work in Earthmoving" was the title of a talk presented by **E. W. Spannhake** (seated center), Le Tourneau Westinghouse Co., at the **Central Illinois Section's** Feb. 25 meeting in Decatur.

Joining speaker Spannhake are Section Chairman **R. D. Henderson** (standing); **E. Brookhouzen** (seated left) vice-chairman for Decatur; and **A. W. Sieving,** technical chairman for the meeting.

3. Center of discussion here is the Briggs and Stratton Corp.'s lightweight die-cast aluminum engine at the **Twin City Section** March 13 meeting.

Shown from left to right are: **Leo Lechtenberg,** development engineer, Briggs and Stratton Corp., who talked on "The Development of Small Air-Cooled Engines"; **Hendrie Grant,** experimental engineer, Scott-Atwater Mfg. Co., who spoke on "Recent Developments in Mid-Range Fuel Economy in Two-Cycle Engines"; and **Ken Robinson,** project engineer, Scott-Atwater Mfg. Co., who gave a talk on "Recent Developments and Engineering Problems in Two-Cycle Outboard Motors."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CINCINNATI

A. R. Ehrnschwender, Field Editor

Members and guests at the Cincinnati Section's March meeting heard **A. E. Kimberly,** chief engineer, DeSoto Division, Chrysler Corp., deliver a both humorous and informative talk on "You Bet Your Life, Test It."

Movies of the Chrysler Proving Grounds test program and the 1956 Indianapolis race climaxed the meeting.

From Section Cameras

1. The various non-classified aspects of the B-52 and the training of its crews were discussed by **Major Allen R. Tennyson** (right), USAF, and **Major Francis E. Dyser** (left) USAF at **Northern California Section's** April meeting. Both are operations officers of the 4017th combat crew training squadron, Castle Air Force Base, Calif.

2. Members and guests of the **Baltimore Section** sit down to a steak dinner before touring the Koppers Co. plant in March.

Surprised guests found piston rings serving as napkin holders at the table.

3. A contingent from the **Baltimore Section** examines the products typical of those which they saw being made during the tour of Koppers Co.

4. Guest speaker at the **Kansas City Section** February 21 meeting, **George M. Galster**, automotive service manager, Champion Spark Plug Co., demonstrates his talk on "Factors Influencing Spark Plug Operations in Modern Engines."

WICHITA

K. W. Rix, Field Editor

Highlight of the Wichita Section's Feb. 21 meeting was a talk on "Beech XKDB-1 Target Drone" presented by **Dr. James F. Reagan**, manager missile engineering, Beech Aircraft Corp., Wichita.

Dr. Reagan supplemented his discussion with slides.

Oregon

A field trip covering four Portland, Ore. companies was the special activity of the Oregon State College SAE Student Branch and SAE Oregon Section members on March 8.

The day's program started off with a tour of the General Motors Training Center at Tigard. The afternoon's activities consisted of a visit to the Instrument Sales and Service, the Lomac Motors, and the Goliath Auto-Haus, Inc.

Briefs of SAE PAPERS

Presented below are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. Order from SAE Special Publications, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ each to members, 60¢ each to nonmembers.

AIRCRAFT

Small Gas Turbine—Problem and Promise, S. ALPERT. Presented Jan., 1957, 11 p. Summary of experience at Solar Aircraft Co. in developing initial design and later application of 50-hp Mars and 500-hp Jupiter gas turbines.

Why Small Engines, D. P. EDKINS, M. H. THORSON. Presented Jan., 1957, 19 p. Small engine is defined as one where primary airflow rate is not more than 75 lb of air per sec at sea level static conditions; this results in various values of output of gas turbines at upper limit, according to type; basis for specific weight advantage and limitations on use of 3/2 or square-cube law; applications to helicopters, VTOL, trainers, drones, missiles; future trends.

Evolution of Gas Turbine, W. E. SKIDMORE. Presented Jan., 1957, 23 p. Highlights in development of small gas turbine at Boeing Airplane Co.'s Industrial Products Div. beginning with laboratory model, operated in 1946, to and including current Model 502-10C 240-hp gas turbine in current production; application and potential.

Some Experiences in Development and Application of Lycoming's T53 Gas Turbine Engine, A. FRANZ. Presented Jan., 1957, 10 p. Basic considerations and design philosophy at Lycoming Div. of AVCO Mfg. Corp. which established design criteria for T53 and T55 gas turbine engines; some of design features, development and application experiences discussed which demonstrated correctness of original concepts.

Experimental Stress Analysis in Small Turbines, G. SORENSON. Presented Jan., 1957, 19 p. Summary of major stress problems encountered during development of small gas turbines at Continental Aviation & Engineering Corp.; problems fall into three categories: steady stress, low frequency, and high frequency stress.

Increased Mission Effectiveness Through Application of Small Gas Turbine Engines, R. C. HENSLEY, N. C. WITBECK. Presented Jan., 1957, 10 p. Relative merits of different scale engines for typical flight applications; analysis of performance characteristics; it is concluded that for typical missions in high subsonic or supersonic speed range small turbojet engine package requires lower weight of engine plus fuel than unaugmented or augmented single large engine of equal thrust.

Visual Study of Ball Motion in High-Speed Thrust Bearing, R. P. SHEVCHENKO, P. BOLAN. Presented Jan., 1957, 16 p. Basic problem of ball action in high-speed thrust bearing was approached photographically in experimental study of ball bearing dynamics by Pratt & Whitney Aircraft Div. of United Aircraft Corp; development, progress and typical preliminary results; analysis of some typical ball motion pictures for particular bearing with and without cage and at variety of loads and speed.

Contaminants and Their Effects on Aircraft Engines, F. E. TOBIN, G. R. FUHRMAN, K. H. STRAUSS. Presented Jan., 1957, 15 p. Investigations in cooperation with airlines and engine builders proved that number of aircraft reciprocating engine irregularities was avoidable because they were direct result of abrasive contaminants; type of damage such as bearing, piston, and ring damage; identification, sources and elimination of abrasive contaminants; suggestions for proper cleaning of parts; applicability to other types of engines.

Discussion of Some Recent Developments in Aircraft Engine Oil Filtration, G. MAY. Presented Jan., 1957, 14 p. Recent developments in scavenge oil filtration and description of composite element stack design having 179-sq in. effective screen area and number of individual symmetrical elements each of which consists of formed aluminum central member, and two screens adjacent to it; application of scavenge oil filtration for both reciprocating and gas turbine aircraft; advantages; chart shows composite element stack flow paths.

Metal Dynamic Hydraulic Seals, G. R. KELLER, P. H. STAFFORD. Presented Jan., 1957, 7 p. Testing and evaluation program undertaken at Autonetics Div. of North American Aviation, Inc., to study performance of metal dynamic seals for use in missiles or aircraft hydraulic equipment in lieu of elastomeric seals which are unsuitable at high speed, high temperature operation; tests at room temperature of seals of various configurations, materials, finishes, etc; shaft seals and piston seals tested at oil temperatures from 500–550 F, diameters ranging up to 3⅜ in.

Progress Report on Rubbing Seals, E. A. RYDER. Presented Jan., 1957,

Continued on page 132

ALTMAN...

... appointed SAE Presidential adviser on small aircooled engines

PETER Altman, vice-president of Continental Motors Corp., has been named by SAE President W. Paul Eddy as a special adviser on SAE's function in the small aircooled engine industry. Increased production and applications to less-than-60-hp units since World War II point to the need for more interchange of technical data. Altman will suggest how SAE can accelerate this interchange on design and production problems. His recommendations will encompass present Society activities.

Since the beginning of the industry in 1921, when the first small engines were used for farm washing machines, production has expanded to more than 4,000,000 engines a year with over 80 applications, Altman reports. The major production is in the ½- to 6-hp range with the self-powered lawn mower the main use. Other leading applications are; garden tractors, cultivators, chain saws, water pumps, sprayers, conveyors, air compressors, auxiliary engine generator sets, scooters, industrial maintenance equipment, construction equipment, truck-trailer and freight car refrigeration (and heating) units.

Program in Progress

Already scheduled are papers for the Summer Meeting in Atlantic City on June 6.

- **European Developments in Small Aircooled Engines**
  By W. E. Meyer, Pennsylvania State University
- **New Small Military Standard Engines**
  By L. D. Bakke, Continental Motors Corp., and R. F. Dennis, U.S. Army Engineer Research and Development Laboratories

During the week of June 2, there will be a display of applications of small engines on the Lounge Floor of the Haddon Hall Hotel. Problems on the production of small engines will also be the subject of a panel at the Production Forum at the National Tractor Meeting in Milwaukee on September 9-12.

Standards on safety, testing of small engines and carburetors have been developed by the Small Aircooled Engine Subcommittee during the past two years. Presently, output shafts and mountings are being developed to aid interchangeability between application and engine. These cover two- and four-cycle lawn mower engines, pumps, and generators.

59 Papers Approved So Far for 1957 SAE Transactions

THE 1957 SAE Transactions is scheduled for publication in August. It will contain about 750 pages and will be clothbound in maroon. It will include an author, title, and subject index covering all papers and their discussions contained in the volume.

So far, 59 papers have been approved by SAE Readers Committees for inclusion in this Transactions. Each of these papers will be printed in full, complete with written discussions of the papers. In some cases, the secretary's report of the oral discussion that took place after the presentation of the main paper is included.

Prices are: $3 to members, $7 to public and college libraries and U.S. Government agencies, $10 to nonmembers; foreign: $3 to members, $8 to public and college libraries, $11 to nonmembers.

The papers approved so far are:

"The New American Motors V-8 Engine"—by **J. F. Adamson, C. E. Burke,** and **D. B. Potter**

"Preignition in Aircraft Reciprocating Engines"—by **J. Anderson**

"An Approach to Obtaining Road Octane Ratings in a Single-Cylinder Engine"—by **E. M. Barber, H. I. Wilson,** and **T. H. Randall**

"Weld Repair of Aircraft Quality Magnesium Castings"—by **W. A. Beck**

"Compressor Stall Problems in Gas-Turbine-Type Aircraft Engines"—by **W. A. Benser** and **H. B. Finger**

"The Experimental Chassis for the Firebird II"—by **J. B. Bidwell** and **R. E. Owen**

"High-Speed Turbopumps"—by **J. E. Boretz**

"Where Does All the Power Go?" This symposium includes: "The Engine—The Power Source"—by **C. E. Burke** and **L. H. Nagler**; "The Accessories—The First Bite"—by **E. C. Campbell**; "Effective Power Transmission"—by **W. E. Zierer** and **L. H. Welch**; "Wind and Rolling Resistances"—by **L. C. Lundstrom**; "What the Customer Gets"— by **T. D. Kosier** and **W. A. McConnell**

"The Continental Mark II—A Design Story"—by **H. F. Copp**

"Compressor and Turbine Matching Considerations in Turboprop Engines"—by **E. H. Davison**

"The General Motors Fuel Injection System"—by **J. Dolza, E. A. Kehoe, D. Stoltman,** and **Z. Arkus-Duntov**

"Dynamic Testing of Seat Belts"—by **D. M. Finch** and **J. D. Palmer**

"Some Effects of Stroke and Bore on Diesel-Engine Performance"—by **K. J. Fleck**

"Observations on 25,000 Hours of Free-Piston Operation"—by **G. Flynn, Jr.**

"Powermatic—A New Automatic Transmission for Chevrolet Heavy-Duty Trucks"—by **H. O. Flynn**

"The Automotive Free-Piston-Turbine Engine"—by **D. N. Frey, P. Klotsch,** and **A. Egli**

"The New General Motors Hydra-Matic Transmission"—by **K. W. Gage** and **P. J. Rhodes**

"The New Dynaflow Automatic Transmission"—by **R. J. Gorsky**

"The Continental 750-Horsepower Aircooled Diesel Engine"—by **H. H. Haas** and **E. R. Klinge**

"Laboratory Fatigue Testing of Gears"—by **J. A. Halgren** and **D. J. Wulpi**

"Some Elements of Gas-Turbine Performance"—by **S. D. Heron**

"Orion—A Gas Generator Turbocompound Engine"—by **R. J. Hooker**

"The Automotive Gas Turbine—Today and Tomorrow"—by **G. J. Huebner, Jr.**

"Reduction of Cavitation Pitting of Diesel-Engine Cylinder Liners"—by **J. A. Joyne**

"High-Speed, High-Output, Loop-Scavenged Two-Cycle Diesel"—by **H. List**

"Motion Sensitivity as a Guide to Road Design"—by **W. A. McConnell**

"Cavitation Control Through Diesel-Engine Water Treatment"—by **W. Margulis, J. A. McGowan,** and **W. C. Leith**

"Winterization of Construction Equipment"—by **M. G. Mardoian, F. M. Baumgardner, J. A. Klisch, W. W. Cornman, T. H. Fones, A. Q. Spitler, and P. W. Espenschade**

"New Drive Lines for New Engines"—by **W. P. Michell**

"Sound and Furor—The Jet Noise Suppression Age"—by **M. M. Miller**

"Temperature-Strength-Time Relationships in Mufflers and for Truck Muffler Materials"—by **C. E. Nelson, W. Chow, P. C. Rosenthal, P. S. Myers,** and **O. A Uyehara**

"Dark Diets for Diesels"—by **G. Neely, E. F. Griep,** and **P. L. Pinotti**

"Stopping Ability of Motor Vehicles Selected from the General Traffic"—by **F. W. Petring**

"Some Aspects of High-Speed Tire Testing"—by **E. F. Powell**

"Automotive Fuel Pumps—A Fundamental Study of Their Performance"—by **R. A. Randall**

"A Basis for Understanding Antiknock Action"—by **E. B. Rifkin** and **C. Walcutt**

"Diesel Exhaust Odor—Its Evaluation and Relation to Exhaust Gas Composition"—by **F. G. Rounds** and **R. W. Pearsall**

"Fundamental Investigation of Noise Generation by Turbulent Jets"—by **N. D. Saunders** and **J. Laurence**

"Radioactive Tracer Measurements of Engine Bearing Wear"—by **M. W. Savage** and **L. O. Bowman**

"Automotive Nuclear Heat Engines and Associated High-Temperature Materials"—by **F. L. Schwartz** and **H. A. Ohlgren**

"Research in the Fundamentals of Automobile Control and Stability"—by **L. Segel**

"Full-Scale Field Service Tests of Railroad Diesel Fuels"—by **R. W. Seniff** and **F. A. Robbins**

"Technical Findings from Automobile Impact Studies"—by **D. M. Severy** and **J. H. Mathewson**

"The Versatile Jet Transport"—by **S. R. Shevell**

"Human Factors of Crash Protection in Automobiles"—by **J. P. Stapp** and **S. T. Lewis**

"Combining the Features of Disc and Shoe Brakes"—by **T. H. Thomas**

"Effect of Fuel Volatility on Starting and Warmup of New Automobiles"—by **H. A. Toulmin, C. T. Moore,** and **R. D. Young**

"The Regenerative Whirlfire Engine for Firebird II"—by **W. A. Turunen** and **J. S. Collman**

"The Applications of Radioactivity for Control and Testing of Automotive Materials"—by **H. A. Tuttle** and **C. E. Noakes**

"GMR 4-4 Hyprex Engine—A Concept of the Free-Piston Engine for Automotive Use"—by **A. F. Underwood**

"Brake Ratings for Automotive Vehicles"—by **R. L. Wehe**

"Convertiplanes and Other VTOL Aircraft"—by **R. J. Woods**

"What Do Calculated Gear Stresses Mean?"—by **E. J. Wellauer**

"Electrojector—Bendix Electronic Fuel Injection System"—by **A. H. Winkler** and **R. W. Sutton**

"Some General Considerations Concerning VTOL Aircraft"—by **C. H. Zimmerman**

SAE National Meetings

1957

June 2-7
Summer Meeting
Chalfonte-Haddon Hall
Atlantic City, N. J.

August 12-16
West Coast Meeting
Olympic Hotel, Seattle, Wash.

September 9-12
Tractor Meeting and
Production Forum
Hotel Schroeder, Milwaukee, Wis.

September 30-October 5
Aeronautic Meeting,
Aircraft Production Forum,
and Aircraft Engineering Display
Ambassador, Los Angeles, Calif.

November 4-6
Transportation Meeting
Hotel Statler, Cleveland, Ohio

November 5-6
Diesel Engine Meeting
Hotel Statler, Cleveland, Ohio

November 6-8
Fuels and Lubricants Meeting
Hotel Statler, Cleveland, Ohio

1958

January 13-17
Annual Meeting and Engineering
Display, The Sheraton-Cadillac
and Statler Hotels, Detroit, Mich.

March 4-6
Passenger Car, Body,
and Materials Meeting
Sheraton-Cadillac Hotel,
Detroit, Mich.

March 31-April 2
Production Meeting and Forum
The Drake, Chicago, Ill.

April 8-11
Aeronautic Meeting,
Aeronautic Production Forum,
and Aircraft Engineering Display
Hotel Commodore, New York, N. Y.

SAE LOOKS OVERSEAS

by PROF. H. A. HAVEMANN, *Indian Institute of Science*

Prof. Havemann, of the Institute's Department of Internal Combustion Engineering, is currently in the United States.

HOT AIR RESEARCH

"The process of heat transfer to a pulsating medium may be modified considerably by the nature and frequency of pulsations imposed on the medium. The change of the rate of heat transfer depends on the frequency of the pulsations and the Reynolds number. . . . The onset of improved heat transfer occurs across a comparatively narrow band of frequencies."

The foregoing are conclusions of a report sent to Dr. C. G. A. Rosen, Chairman, SAE Overseas Information Committee, by Prof. H. A. Havemann, Department of Internal Combustion Engineering, Indian Institute of Science, Bangalore-3, India. Purpose of this research is to develop small powerplants in low horsepowers for rural and remote areas in India where conditions could favor the use of the hot air engine.

HEAT TRANSFER RATE OBSERVED

The report deals with a problem involved in the design and operation of the heat exchanger of a hot air engine. The problem is to determine the rate of heat transfer between a hot tube and air flowing in it turbulently, when pulsations are imposed on the air. A model heat transfer investigation was conducted with air flowing unsteadily in, and completely interrupted by pulses through a horizontal brass pipe of 1 in. inside diameter which was heated externally by steam. The Reynolds numbers calculated for equivalent steady flow conditions ranged from 6,000-25,000 and the frequencies from 5-40 cps.

An increase in the rate of heat transfer was observed only within a limited range of frequencies and at certain Reynolds numbers. A marked improvement of the rate of heat transferred could be obtained by fitting an orifice plate as a constriction to the end of the heat transfer pipe whereby pressure waves were reflected and the previously obtained dependence of air pressure on time and locality was altered.

HEAT EXCHANGE EFFICIENCY FACTOR

The efficiency of a hot air heat exchanger is one of the most important factors deciding the overall efficiency of the powerplant. An increase of the heat exchanger efficiency from 80 to 85% is equivalent to raising the maximum temperature of the cycle by nearly 150 C. The heat exchanger also adds bulk to the hot air engine and

(continued on page 104)

This feature is an activity of the SAE OVERSEAS INFORMATION COMMITTEE, C. G. A. Rosen, chairman

Anodized Aluminum Alloys Used for Varied Coatings

Based on paper by

R. V. VANDEN BERG

and

D. J. GEORGE

Aluminum Co. of America

ANODIC oxidation of aluminum alloys makes possible a variety of different finish characteristics in both decorative and protective coatings. Such coatings reproduce the texture from which they are formed.

Alcoa has had in commercial use for a number of years a nomenclature system for the surface pretreatments, in which letter designations are used to denote the various preparatory treatments, including both chemical and mechanical types.

(This system and the specific manners in which it is applied in the various methods of designating anodic finish are described in detail in the paper, "Characteristics of Anodized Aluminum Alloys" from which this digest was made. Complete paper is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Small Turbines Have Manifold Uses

Based on paper by

D. P. EDKINS

and

M. H. THORSON

General Electric Co.

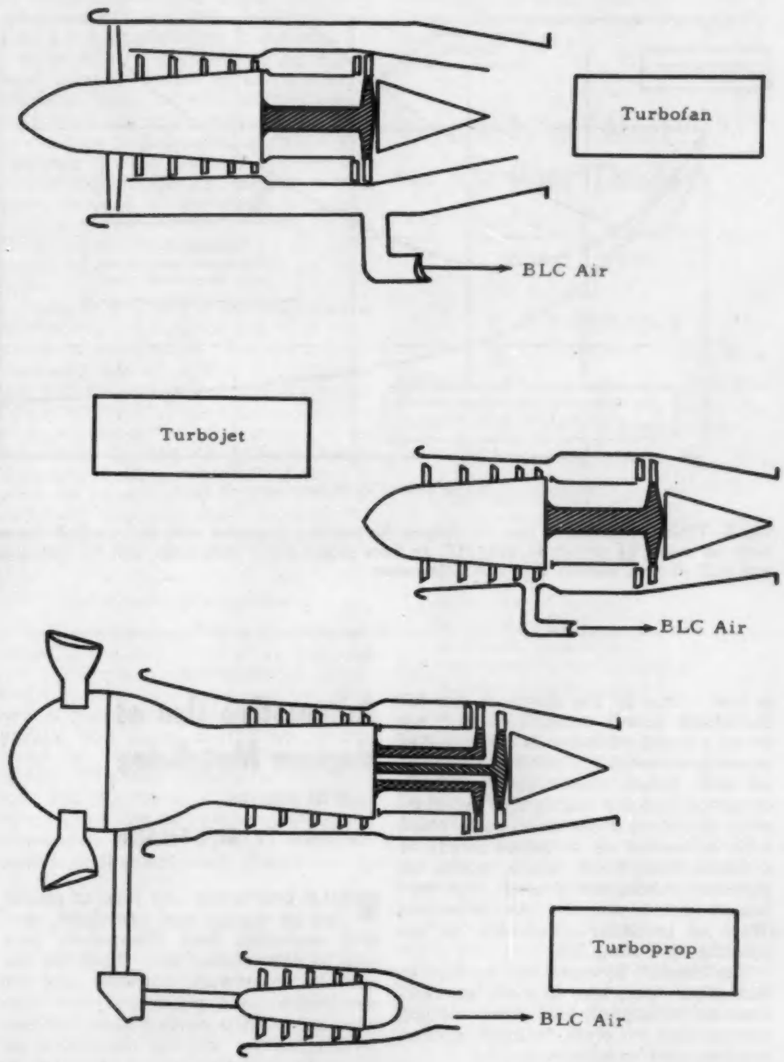

Fig. 1—Various ways of obtaining air for boundary layer control, or other purposes, from three basic types of gas turbine engines.

THE 4500–5000-lb thrust or 7500–8000-hp gas turbines, although small in comparison with the largest now under development, have many uses. They will not be entirely supplanted by their big brothers.

For example, numerous boundary layer control applications will be found in the near future as the availability of small lightweight gas turbines increases, since the benefits range all the way from small improvements in existing techniques to great strides in aerodynamic performance and efficiency.

The various ways of obtaining air for BLC, or for other purposes, from gas turbine engines of the three basic types is illustrated in Fig. 1.

The gas turbine with the smallest inherent air supply is the turboprop or turboshaft engine. Air bleed from the main cycle rapidly destroys the ability of this engine to do its job because this air is also the life blood of the engine cycle itself. Only small amounts of bleed air can be taken before the loss in engine power becomes prohibitive. However, since the output of the engine is in the form of shaft rotation, it lends itself readily to the production of air for boundary layer purposes by connecting mechanically to a load compressor, and the amount of power which can be absorbed in this way is again one of overall expediency like the turbofan. The turbojet is midway between these two in its ability to provide air, and a figure of 7% of the total airflow is typical.

The different behavior of gas turbines when used to supply air, by one means or another, is shown in Fig. 2. Note the typical reductions in take-off distance with turbofan propulsion with BLC air from the bypass duct, and with turboprop propulsion with BLC air from an engine-driven compressor and from a separate engine and compressor.

The turboprop curves include the effect of propeller slipstream on the airplane wing lift. The curves show the effect of using air for the reduction of takeoff distance by flap blowing with a turboprop, with both a load compressor and with a separate auxiliary powerplant driving a compressor, and with a turbofan where the bypass air

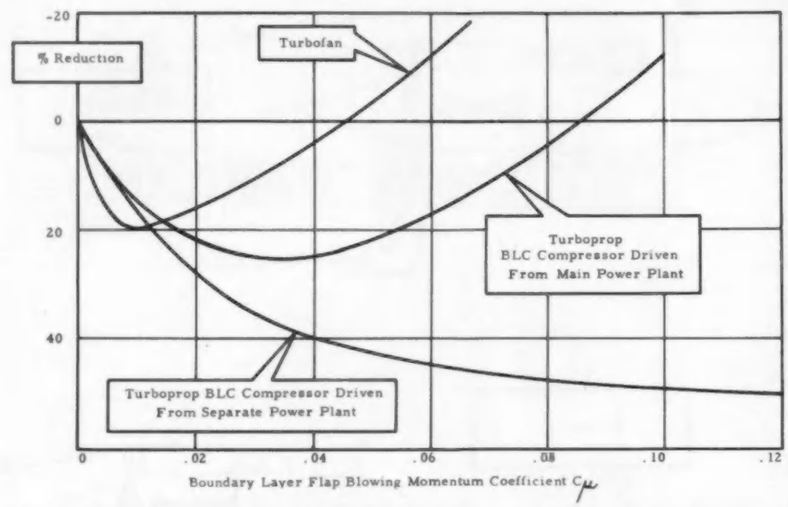

Fig. 2—Typical reductions in take-off distance for turbofan propulsion with BLC air from bypass duct, for turboprop propulsion with BLC air from engine-driven compressor, and for turboprop with BLC air from separate engine and compressor.

is bled. Due to the shape of the lift increment versus amount of BLC air curve, a rapid reduction in take-off distance is achieved for small amounts of air and, hence, either an actual increase of distance (because of deterioration of output of the main powerplant with increasing air or power bleed) or a much diminished return where an auxiliary powerplant is used. The turboprop curves include the beneficial effect of propeller slipstream in increasing the wing lift.

The "small" turbines will be sure to find other uses, too, in such applications as helicopters and other vertical take-off and lift craft, trainers, drones, missiles, and small transports.

(Paper, "Why Small Engines?" on which this abridgment is based is available in full, in multilith form from SAE Special Publications, 485 Lexington Avenue, New York 17, N. Y. Price: 35¢ to members: 60¢ to nonmembers.)

Automotive Use of Vacuum Metalizing

Based on paper by

V. M. STILSON

The Erie Resistor Corp.

WHILE practically any type of plastic can be coated and metalized, several materials lend themselves very well to this kind of use. Thus far the acrylics, butyrates, styrenes and its copolymers, and phenolics have been used because the coating materials and techniques for surface metalizing on these plastic materials is perfected to a greater extent than any other.

Selecting the Material

Selection of the plastic material to be used, should to a large extent determine the finishes to be used.

The first step, after precise information is available on the material used in molding, is to select a base coating. This base coat serves several purposes. But its main objective is to provide adhesion to the plastic part and prior to vapor metalizing.

It must also provide a good, smooth base and be of a nature so as not to attack the metal finish. In some cases, it must supply the texture and tone of the finished part. It must be capable of being wetted with the metallic coat and must form a strong bond with the top coat and the metal. The coating in itself should outgas very little and must form a barrier coating for those plastics (such as the butyrates) which have a decided tendency to outgas during metalizing.

Methods of Application

Several methods are available for applying the coatings. Those most generally used are dipping, hand spraying, flow coating, and automatic machine spraying. Atmospheric conditions must be ideal for good results.

Depending on the method of coating used, the solvent system must be selected to obtain a smoother and uniform coating free of runs and sagging. Needed also is viscosity control of the coating and the coating kept free of all particles and dirt, resorting to filtering as required.

Particles of dust are magnified in subsequent operations. If the moisture content of the ambient air is high, poor adhesion results.

Several types of prime coats are available, both air and force dried. The base coat will vary with the type of molding compound used in producing the plastic part.

Applying the Vaporized Metal

The second operation involves the application of the vaporized metal itself to the base coated part.

A large bell or tank capable of holding a considerable number of parts, and constructed to allow pumping down to internal pressures to fractions of at least ½ micron, or better, must be available. Usually, in the center of the racks filaments are provided of tungsten on which metal wire staples are suspended.

After loading, the tank is pumped down and the filaments are heated to a white heat. If the tank has been properly pumped down, there should be achieved a bright metallic finish from the process.

There is reason to believe that humidity influences the pumpdown time on vapor metalizing equipment. The higher the humidity, combined with elevated temperature, the longer the time required to evacuate the air from the chamber. Operating on this hypothesis, plus the necessity for clean air, the case for air purification and

Renault's Dauphine Has 50-hp, 1000-kg Engine

Renault's rear-engined Dauphine car, discussed in an article starting on p. 39 in the April SAE Journal had a flagrant typographical error in its first line. Instead of noting the horsepower of the engine as 50, the article said 5-hp.

The engine does have 50-hp.

humidity and temperature control becomes stronger.

The application of the top coat is the final operation. This can be done by dipping, or spraying manually or automatically.

(Paper, "Automotive Application of Vacuum Metalizing" on which this abridgement is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Prices: 35¢ to members; 60¢ to nonmembers.)

Antiknock Quality Measured by T/D Method

Excerpts from paper by

BRUNO SIEGEL
Sinclair Research Laboratories, Inc.

Fuel-engine adaptation work can be simplified by describing both fuel and engine behavior on the basis of compression temperature and compression density, since these two factors predetermine the combustion characteristics of fuels as well as engine fuel requirements. Since it is difficult to obtain instantaneous measurements of these factors, calculated values were used.

Categories of Classification

Use of the *T-D* parameters has the potential of replacing all present ASTM engine test methods and CRC road testing techniques. A critical examination of past and present testing and analytical techniques concludes that many engine performance characteristics are unsuitable as variables for forcing fuels into the knocking zone. That is, such relationships as spark advance, rpm, *A/F* ratio, or compression ratio, which plot parabolically against power or efficiency, do not permit description of fuel quality over a large enough range of operating temperatures and pressures. In contrast, knock-limited manifold air pressure relationships plot hyperbolically and therefore permit rectification of data by extending graphical treatment to logical termini. This in turn, results in the development of stable mathematical formulas for rigid classification of pure hydrocarbons with respect to their knocking behavior.

Improvement of Test Methods

It is demonstrated that the fundamental limitations of existing test methods can be eliminated by operating the laboratory engine at constant fuel/air ratio, peak power spark, and by using manifold air pressure to stress fuels into the knocking zone. Data obtained in this manner can be analyzed to describe fuel antiknock or anti-preignition quality at an infinite number of combinations of compression ratio, inlet temperature, and manifold pressure by a single curve or formula.

Fuel additives, especially tetraethyl lead, produce bulges in the curves of the base fuels. These secondary curves emanate from and return to the curve of the base fuel, depending on the *T-D* response of the additive. There are strong indications that the effect of a given amount of tetraethyl lead in a fuel over the realistic compression temperature range assumes a parabolic relationship easily expressed by formula.

Tests in progress at our laboratories have covered a range of 1000 R in compression temperature. They have demonstrated the feasibility of constructing *T-D* frameworks of blends of pure hydrocarbons. These frameworks can be superimposed on one another to relate their combustion characteristics. The intersections of the *T-D* lines of pure hydrocarbons are also used to calibrate the laboratory engines for exact agreement with published frameworks.

Establishing Fuel Requirements

Fuel requirements of full-scale engines on the test stand or on the road (on a *T-D* basis) are established by operating the engine under well-specified sets of operating conditions and determining the exact blends of various types of reference materials which knock. The combination of temperature and density at which the laboratory engine has to be operated to rate these same blends equal is then ascribed to the full-scale engine as its "*T-D* requirement."

Other Test Results

Byproducts of the tests were the discoveries that (1) the existing octane-number scale can be utilized by use of a linear relationship which also permits logical extension in both directions, (2) the earlier findings of D. B. Brooks that the absolute end of the octane-number scale is 130 "octane" could be substantiated, (3) it would be ill-advised to associate an extended octane-number scale with only one other set of reference materials such as isooctane plus tetraethyl lead and (4) the differences in the shapes of the *T-D* curves of leaded and nonleaded fuels offer a plausible explanation of the long-standing paradox that engines become "milder" as compression ratio is increased, while physical law says this cannot be true.

The paper summarizes 14 practical applications including suggestions for new control and auxiliary test methods for studying knock and autoignition behavior on a much broader basis than is possible with ASTM methods.

(Paper, "Use of Temperature-Density for Measuring Antiknock Quality" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Versatility a "Must" For Car Body Finishes

Based on paper by

J. D. PICKENS
and
T. R. MATTHEWS
E. I. du Pont de Nemours & Co.

THERE have not been available film formers which yield all these desirable properties in a single finish:

- Good stain resistance
- Rapid dry
- Easy spot repair
- Resistant to overbake discoloration
- High initial hardness
- Glamorous appearance
- High solids
- Low solvent costs
- Nonbuffing finish
- Improved durability
- Improved blister resistance
- Extended color range

Yet it is clear that such a variety of characteristics is needed.

An automobile body finish has to be one of the most versatile finishes known. To attract the car buyer, it must be available in an extremely wide and ever-changing variety of attractive colors. It must withstand desert heat and sun without becoming soft and withstand subzero temperatures without becoming brittle. It must withstand constant exposure to sun, rain, ice, and snow without premature dulling, cracking, or other failures. It must be abrasion-resistant in order to withstand wear. It must be adherent and flexible to withstand reasonable mechanical damage and abuse. It must be capable of repair in the field as well as on the production line. So, it is not surprising that many candidates for new automobile finishes never get beyond the laboratory stage. Each one may be outstanding in some properties, but all too often it fails to meet minimum standards in other respects.

Du Pont believes that its recently developed lacquer and enamel provide a car finish that will retain a high luster and remain undamaged by the elements longer than conventional finishes.

(Paper, "Two New Automotive Topcoats 'Lucite' Acrylic Lacquer and 'Dulux 100' Enamel" on which this abridgement is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Hot Day Cuts Payload Allowable at Jet's Take-Off

Based on paper by

D. W. FINLAY

chief of preliminary design, Transport Division, Boeing Airplane Co.

The jet engine tends to be a constant-volume air pump and derives its thrust from increasing the energy level of the air mass passing through it. The effect of increased temperature in the air mass being breathed by the engine is to (1) reduce the weight flow of the air and to (2) increase the temperature of the air mass prior to the time that heat energy is added by the combustion of fuel. The combination of these two effects results in rather a more substantial reduction of power available out of the jet engine than was true for the piston engine—propeller combination with which we are familiar.

The economic effects of elevated temperature operation for four-engine jet transports are primarily due to deterioration of take-off load-carrying capability.

For a specific jet transport airplane employed in operations requiring either little elevated temperature operation or at ranges not exceeding about two-thirds the ultimate range capability, the effects of elevated temperature operation are negligible.

For the more normal case in which the operator desires to provide flexibility in equipment for assignment to all parts of a large route system entailing long range, as well as tropical, desert, or mid-continent summer operation, some form of take-off thrust augmentation is desirable.

The final choice of augmentation means is dependent upon the detail nature of the operation planned for the airplane as well as upon consideration of the relative availabilities of powerplants suited for the job to be done. Some means of increasing the ratio of take-off thrust to all other thrust characteristics of the engine is indicated, because when jet engines are sized to the airplane for optimum economy in the cruise case, they tend to be significantly undersized in the take-off case, particularly at increased temperatures.

(Paper, "Effect of Hot Day Performance on Jet Transport Economics" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Prerequisites for High Drive Seal Performance

Based on paper by

M. C. KEYS

and

F. S. ENGELKING

Caterpillar Tractor Co.

FOR a tractor final-drive seal to perform efficiently:

1. There must be ample space allotted to permit sufficient bellows movement.
2. The bellows must transmit torque without any sticking or binding within the bellows and present a seal surface which is uniformly loaded by the bellows.
3. The bellows boot material must be immune to flexing and abrasion and must not reduce the spring load while operating in the normal space range.
4. The seal load must be high enough to achieve sealing and the materials chosen so as not to generate destructive temperatures.
5. The seal area must be small enough to give high unit pressures for good sealing but large enough for a long wear life.
6. The cork composition seal material should be as near the OD of the seal-ring-carrier plate as possible and should have a spherical grinding at the time of assembly. In addition, the seal material should have good compressibility and resilience and be nonporous.
7. The wear washer should be wear resistant, smooth, and as flat as possible.
8. The gasket between the wear washer and sprocket must be uniform in thickness and a sealant must be used on both sides of the gasket.

(Paper, "Resilient Face Seals for Tractor Final Drives" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Army Gets Design Tips From Civilian Vehicles

Based on paper by

Col. J. J. WILSON

U. S. Army Armor Board

THE Army is looking for wheeled vehicles which will meet the demands of a Third World War. Investigation of present civilian designs for the purpose of finding the best military designs reveal that:

1. If you want more off-road mobility, use a larger diameter tire since it provides better load capacity with more ground clearance, less rolling resistance, and because of lower tire pressures, more traction with better floatation. It has other advantages such as longer life due to the greater periphery and cooler-running characteristics.
2. To steer large tires with greater agility than found on conventional vehicles, use positive-powered wagon steer.
3. To provide floatation in water, use exoskeletal design.
4. To save weight and simultaneously improve durability and reliability—simplify. Simplification can be had by:
   a. eliminating suspension systems and, in turn, articulating power trains by the use of large-diameter tires.
   b. eliminating body rack and exposed steering linkage by the use of positive-powered wagon steer.
   c. eliminating bodies and beds bolted to the chassis by the use of exoskeletal monocoque inherently-floating construction.
   d. using only four wheels, sufficiently large to simultaneously carry the weight and provide the mobility.
5. Most vehicles should be designed to perform a specific task and as a consequence the Army needs and should develop:
   a. airliftable, floating, battlefield vehicles.
   b. airdroppable, floating, distribution vehicles.
   c. logistic vehicles capable of unit disassembly into air transportable loads, and capable in some models of floating in inland waterways.

(Paper, "The Army's Wheeled Vehicles" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

SAE LOOKS OVERSEAS

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any increase in efficiency can be directly utilized for its reduction.

The heat exchanger in a hot air engine enjoys a particular mode of operation not usual for normal heat exchangers. This is the occurrence particularly on the cold side, of pressure pulsations of the air flow. It therefore becomes desirable to investigate the effect of these pulsations on the heat transfer coefficient. The report examines whether pulsations imposed on, and completely interrupting, a flowing fluid with varying pressure amplitude and frequency have any effect on the rate of heat transfer to this fluid.

The report is well documented with considerable experimental data from a variety of sources which should prove interesting to those investigating the old, but fascinating, subject of hot air engines.

SAE CEP COOPERATIVE ENGINEERING PROGRAM NEWS

Transmission Friction Explored By New Subcommittee

ACCURATE testing of friction materials and parts in transmissions is the objective of the new Friction Subcommittee of the SAE Transmission Committee.

In the past, there have been approximately as many frictional test setups as there have been different transmissions. Consequently, very few fundamental test results have evolved which could be used to forecast frictional behavior in any given new environment. Each new design has had to be practically custom tailored.

Friction Tests of Past

The large majority of past friction tests have been of the inertia type. For example, a large mass might be spun to a definite speed, and then the frictional element engaged, and the inertia mass slowed down to a standstill by the frictional work. In some respects, this is similar to transmission requirements.

Operating environments can be as much a factor of the test results as the frictional materials, oils, and surface finishes. Environmental factors, such as the mass of adjacent metal parts, heat transfer, the quantity of oil present, groove configuration, and rigidity of parts, control the temperature that exists on the surface of the friction members. Therefore, until surface temperature in a friction test can be controlled, there will be as many different values for the friction coefficient as there are transmissions and test machines, each possessing its own inherent temperature control. The new Subcommittee will try to establish a method and a fixture in which the frictional heat is controlled. This is being done to determine reproducible baseline frictional properties of friction materials, oils, and surface finishes.

The actual friction curve in any given transmission will be a cross plot from the family of controlled temperature curves which will be determined. Fig. 1 illustrates a hypothetical group of friction cofficients plotted against slip velocity at three different controlled temperatures. By cross plotting, the actual output friction curve for the transmission might well have a shape similar to the dashed line in the graph.

The static friction cofficient value as well as the whole friction curve is of importance. It is the static cofficient that finally locks the clutch members together at a one-to-one ratio. For many years, it was believed that static coefficient was always higher than the kinetic coefficient. Recent tests at constant temperature have shown that with many Type A oils, the static coefficient is as much as 50% below the average kinetic friction coefficient value. When this condition develops, a very critical problem arises in the calibration of the apply pressure required to satisfactorily engage the friction elements. Shift feel dictates that the apply pressure must not be too high during the engagement or a harsh shift will result; but if there is to be no creep at near static conditions with the falling coefficient, the apply pressure must rise. If apply pressure does not match this coefficient requirement, the friction surfaces will creep and result in a regenerative condition that could overheat and eventually burn out the elements. The unfortunate point is that these friction curves are not constant for Type A oils. Additives in the oil can vary the shape of the curves greatly, especially at low velocities.

Fixture and Method Being Tested

A fixture and a method are presently being tested which the new Subcommittee believes may lead to a solution to these difficult problems, both from the friction material standpoint and friction properties of oils used.

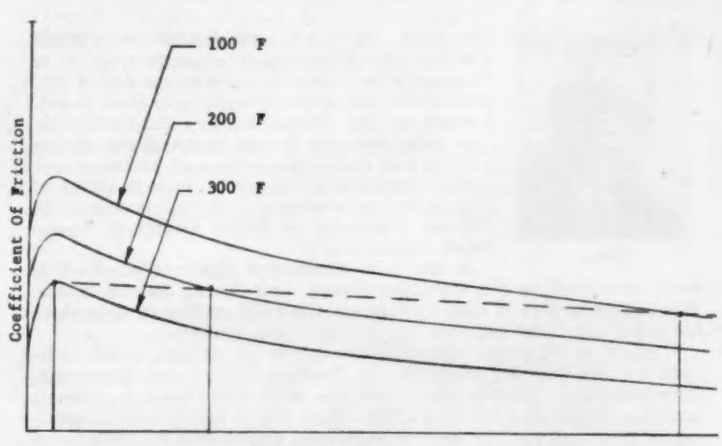

Fig. 1—Constant Temperature Tests vs. Transmission Conditions Illustration

Technical Committee Profiles

Hautzenroeder

HIGHER CAPACITY FRONT TIRES for tractors carrying heavy-duty equipment and additional rear tire sizes are being studied by the Tractor Tire Subcommittee, reports **R. W. Hautzenroeder,** chairman of the parent Tractor Technical Committee. Soil compaction by tractor tires is also being explored by the Subcommittee with the cooperation of the Department of Agriculture.

Four major SAE technical committees have joined forces to research human tolerance to shock and vibration. The Joint Committee includes the Construction and Industrial Machinery Technical Committee, Tractor Technical Committee, Transportation and Maintenance Technical Committee, and the Truck and Bus Technical Committee.

Hautzenroeder, who is chief project engineer for tractors at Massey-Harris-Ferguson, Inc., states the Agricultural Tractor Test Code Subcommittee has several projects under way. One will establish a testing procedure more suitable for tractors equipped with torque converters. Another will establish more realistic hp correction factors.

Hense

CONSIDERABLE WORK ON RESIDUAL STRESS has been going on in the Iron and Steel Technical Committee, reports Chairman **V. E. Hense.** Preparations are being made for publication of D. E. Martin's "Evaluation of Methods for Measurement of Residual Stress." The report, which has been designated TR 147, will appear in booklet form in the future.

Currently, hardenability standards of carbon steels are being developed within the ISTC. Seam depth and decarburization limits of wrought steel are also being established.

The 30 active divisions of the ISTC are composed of over 500 metallurgists who continually act to keep the SAE Handbook up-to-date. Their work involves much liaison work with the American Iron and Steel Institute.

Chairman Hense, who is chief metallurgical engineer at the Buick Motor Division of General Motors, is also a participating member of SAE's Engineering Materials Activity Committee.

Wilson

15 NEW 12-VOLT STORAGE BATTERY GROUP SIZES ranging in capacity from 45 to 70 amp-hr in 5 amp-hr increments with 4 different terminal arrangements have been standardized by the Storage Battery Subcommittee. The Subcommittee is now studying the charge voltage and charge acceptance of batteries over a wide temperature range in various states of charge and at various age levels, reports **H. D. Wilson,** chairman of SAE's Electrical Equipment Committee.

A flat type disconnect terminal standard is being developed by the Conduits, Cables, and Wiring Subcommittee. The Subcommittee is also working on the color coding of 6-conductor connectors used between truck-tractor and trailers.

A study of regulator compensation curves of voltage versus temperature was recently made by the Starting Motors and Generators Subcommittee. Results show that the wide differences in current practice cannot be reconciled at this time due to differences in application and regulator designs, says Wilson, senior product design engineer, Ford Motor Co.

Winterization Group Storms Alaska, Canada

TO appraise construction equipment operating problems, material failures, and crew comfort in subzero temperatures, 12 members and consultant-guests of the Construction and Industrial Machinery Technical Committee's Winterization Subcommittee visited Canada and Alaska in January. There, they conferred with personnel at Department of Defense Headquarters, Western Command, Edmonton, Canada; Northwest Highway System Headquarters, Whitehorse, Yukon Territory; Ladd Air Force Base, Fairbanks, Alaska; and Eielson Air Force Base, approximately 40 miles from Fairbanks.

Test Equipment

Four pieces of winterized equipment were tested near Ladd Air Force Base. They were the Allis-Chalmers HD-16A, Caterpillar D-7, International Harvester TD-18 Tractors, and an Austin Western 99L Grader, powered with Detroit Diesel, Model 4-71.

Engine Starting—Engines require approximately one hour of preheating by portable Herman Nelson heaters before starting in Edmonton. Hauk or Continental type torches are commonly used for preheating. Propane and butane are used as hand torch fuels.

Lubrication Oils and Grease—SAE 10 is generally used for subzero temperatures. Grease is used extensively. In extreme subzero temperatures, when starting difficulty is anticipated, equipment would be left to idle at approximately 700 to 1000 rpm, at the discretion of the operator.

Fuels—Since there is little choice of subzero fuels in Edmonton, a No. 1 fuel oil having a pour point of approximately −40 F is used. Operation at lower temperatures requires heating of fuel.

Batteries—Heavy loads, low charging rates, breakage, freezing, and poor maintenance account for battery problems encountered in subzero temperatures. General heavy-duty commercial types of batteries are used. The Heavy-Duty MIL-B-11188 cold weather battery is not available in Edmonton either through military or commercial sources.

Cabs for Equipment—Cabs for graders, shovels, drag lines, and cranes are accepted by military and commercial users. Cabs for crawler type tractors at present consist of a canvas shroud placed around the tractor and operator, enabling utilization of heat from the engine compartment for operator comfort. Several opinions expressed by commercial users pointed out that conventional cabs for tractor work would be impractical and quite dangerous for sled train operations. General opinion in Edmonton was that the

cost of cabs and maintenance might be prohibitive, and that crew comfort would be the responsibility of the operator.

In Edmonton, temperatures frequently drop to − 35 F, at which time outside operations are discontinued until the weather moderates. However, oil field operations continue regardless of severe temperatures.

Fans and Winter Fronts—Both from a military and commercial point of view, there was a desire for automatic fans which would eliminate the need for winter fronts.

Metallurgical Failures—Low temperature fatigue breakage occurs on graders, blades, dozer corners, and edges from − 35 F down. Military and commercial users feel that a definite improvement is required regardless of additional cost in incorporating cold weather properties to eliminate low temperature fatigue.

Maintenance—The Subcommittee felt that additional training of operators and operational mechanics would be beneficial. This observation was based on indications that personnel responsible for maintaining hydraulic systems, batteries, and battery charging generators have insufficient basic knowledge of equipment assigned them.

Alaskan-Canadian Opinion

At Whitehorse, opinions paralleled those expressed in Edmonton. However, considerable interest was registered in preheating engines for starting, and the installation of a shield around the operator at − 65 F. Highway inspectors expressed particular interest in cab problems. Some contractors indicated a willingness to pay more for winterized cabs. For those operating in remote areas where there is danger of breaking through frozen lakes or muskeg, a preference was shown toward canvas-shrouded rather than glass-enclosed cabs. Shrouds eliminate the danger of frozen brush and trees shattering glass.

An inspection trip of Ordnance equipment and shop procedures was conducted at Eielson Air Force Base.

Gen. Tulley Extends Invitations

Invitations were extended by Maj.-Gen. David H. Tulley, Commanding General, U.S. Army, Engineer Research and Development Laboratories, Fort Belvoir, Va. Arrangements for the trip were made through the U.S. Army Mechanical Engineering Department, Fort Belvoir.

Eight members of the Winterization Subcommittee who made the trip are: Chairman M. G. Mardoian, International Harvester Co.; Co-chairman W. W. Cornman, Allis-Chalmers Mfg. Co.; F. M. Baumgardner, ERDL, Fort Belvoir; T. H. Fones, Caterpillar Tractor Co.; H. G. Haines, Detroit Diesel Engine Division, Allis-Chalmers Mfg. Co.; and Robert Shaw, Ordnance Tank Automotive Command, U.S. Army, Detroit Arsenal.

Consultants and visitors who partici-

Technishorts . . .

Precision Control Motors, a proposed Aeronautical Recommended Practice, is being circulated for comment to AIA's Electronic Equipment Committee and SAE's Aircraft Electrical Equipment Committee. Compiled by SAE's Precision Servo Motors Panel, the document has been in preparation approximately three years.

A proposal on flywheels applicable to industrial engines has been submitted to the Engine Committee by the Construction and Industrial Technical Committee's Subcommittee VI. It is being checked to see if it is correct for other applications, and to expand the size range. The proposal results from cooperative work conducted by the EC's Clutch Housings, Clutch Mountings, and Flywheels Subcommittee and the CIMTC's Subcommittee VI. The two groups have been attempting to standardize and simplify pot and flat type flywheels for use with single plate spring loaded clutches since 1951.

Two instruments which consistently read the intensity of vehicular radio interference between 30 and 400 megacycles are now available, reports the Vehicular Radio Interference Subcommittee studying instrumentation. The Subcommittee, which is part of SAE's Electrical Equipment Committee, is trying to correlate its current activities with those of interested governmental and commercial groups in a cooperative effort to establish acceptable interference limits through a testing program.

The SAE Automatic Transmission Terminology section of the Passenger Car Automatic Transmission Test Code Standard has been renamed **Automatic Transmission Functions.** It was revised recently, and designated an SAE Recommended Practice to appear in the 1957 SAE Handbook.

A survey to obtain data on machinability for both carbon and alloy steels is being conducted by Division 11, Machinability, of the Construction and Industrial Machinery Technical Committee. It will be circulated to the CIMTC with a statement that the Machinability group is reviewing, expanding, and adding alloy machinability ratings to the present ratings as they appear in the 1956 SAE Handbook.

Aluminum Casting Alloys, an SAE Standard, was recently revised by the Nonferrous Metals Committee. It will be available as a Technical Report after June 15. The revisions incorporated chemical composition changes in several aluminum casting alloys and alloy ingots.

Automotive Transmission Terminology, a new SAE Recommended Practice, establishes suitable terminology for various kinds of automotive transmissions and related components. **Temperature Instrument Mounting,** a new SAE Standard, was developed to provide interchangeability of components in transmissions. **Industrial Tractor Front-End Shovel and Loader Nomenclature,** a new SAE Standard, was developed by the Construction and Industrial Machinery Technical Committee.

Winterization Group Tackles Sub-Zero Operating Problems

The SAE Winterization group is pictured above at Western Command Headquarters, Edmonton, Alberta, Canada; Front row, l. to r.: J. H. Hyler, LeTourneau-Westinghouse; Lt. Col. R. H. Young, Command Engineer, Western Command; Winterization Subcommittee Chairman, M. G. Mardoian, International Harvester; M. R. Nicholson, Allis-Chalmers; Secretary W. W. Cornman, Allis-Chalmers; P. W. Espenschade, U. S. Army Engineer Research and Development Laboratories (ERDL), Fort Belvoir, Va.; Robert Shaw, U. S. Army Ordnance Tank-Automotive Command, Detroit Arsenal; J. P. Gardner, Allen Industrial Products.

Second row, l. to r.: F. T. Durrant, Royal Canadian Air Force; Lt. Cmdr. J. P. Croal, Royal Canadian Navy, Defense Research Board; J. W. Gillies, Defense Construction Ltd. (1951); T. H. Fones, Caterpillar Tractor; F. M. Baugardner, U. S. Army ERDL; E. M. Plunkard, Perfection Industries; T. A. Harwood, Canadian Defense Research Board; and H. G. Haines, Detroit Diesel Engineering Division, GMC. (Story begins on page 106.)

pated in the field trip were:

P. W. Espenschade, ERDL, Fort Belvoir; J. Gardner, Allen Industrial Products, Inc.; G. L. Neely, Standard Oil Co. of Calif.; E. Plunkard, Perfection Industries, Inc.

Other active Winterization Subcommittee members not able to make the Canadian-Alaskian trip are: R. J. Bernotas, Euclid Division, GMC; H. A. Crawford, Hercules Motor Corp.; and H. M. Reichert, Waukesha Motors.

Naval Aviation Supply Office Visited

To see how the Navy handles logistics, supply, and maintenance of hardware items, the Engine and Propeller Standard Parts Committee of SAE's Aircraft Engine Division visited the Navy's Office of Aviation Supply in Philadelphia during its March 19–21 meeting. Many of the items surveyed were the product of SAE standardization work.

Foreground, left to right: M. E. Mills, Elastic Stop Nut Corp.; M. L. Stoner, SAE Staff; G. Carvelli, Wright Aeronautical Division; W. P. English, Fairchild Engine Division; J. F. Romary, Curtiss-Wright Corp.; H. McFarland, General Electric Co. Second row, l. to r.: E. F. Gowen, Standard Pressed Steel Co.; Vice Chairman V. E. Newman, Wright Air Development Center; H. M. Favor, Allison Division, GMC. Third row, l. to r.: G. M. Garcina, Allison Division, GMC; Chairman F. G. Miker, Bureau of Aeronautics, Navy Department; Secretary R. L. Keene, General Electric Co.; H. D. Culham, Orenda Engines, Ltd; A. C. Johnson, General Electric Co.; O. D. Lambirth, Westinghouse Electric Corp. Standing, l. to r.: Host H. I. Hoot and Capt. H. J. P. Foley, Jr. of the Navy's Aviation Supply Office. The committee will meet again May 6–8 in Florida.

Improved Gear Lubricants Demand New Designations

NEW and improved multi-purpose gear lubricants necessary for high-speed, high-torque axles are rapidly replacing former gear lubricants used by service stations. The present definition has become out-dated, states the American Petroleum Institute's Operating Committee.

A joint meeting of SAE's Transmission and Axle Lubricants Subcommittee and the API's Automotive Gear Lubricant Panel will be called to discuss the development of a new designation describing improved lubricants. SAE's Transmission and Axles Lubricants Subcommittee will assist in revising the existing designation to enable car manufacturers to incorporate the new designation in instruction book recommendations, denoting the type of product required for field servicing of axles.

Interchangeability Study of New Boss Design Group

INTERCHANGEABILITY design of different hydraulic "O" ring fittings and their bosses is under way in the newly formed Boss Design Subcommittee. Findings will be reported to the Tube, Pipe, Hose, and Lubrication Fittings Committee.

Supplying pumps, valves, and actuating cylinders for ground vehicle and industrial equipment is costly and complicated when identical items must be stocked with different port designs. Also, the user is restricted to one style of fitting when making field replacements. The present SAE "O" ring fitting standards will be compared with other similar fittings to see if a universal boss can be developed to accommodate several types of fittings. Boss and fitting design were examined at the first meeting on March 5, 1957. A desire for minimum changes in the present standards and other designs required a broadening of scope to consider fittings as well as bosses.

V. P. Donner, International Harvester, is chairman of the new subcommittee. Members serving with him are: W. A. Hertel, Weatherhead Co.; T. E. Lyon, L & L Mfg. Co.; L. H. Schmohl, Parker Appliance Co.; and D. F. Stranberg, Anchor Coupling Co.

Jet Fuel Ignition Probed at Wings Club

CONCERN over the unqualified use of the term "safe fuels" was expressed by D. N. Harris, manager of Aviation Products, Shell Oil Co., as he spoke to the Aircraft Gas Turbine, Ram-Jet, and Rocket Engine Ignition Subcommittee of SAE's Ignition Research Committee.

Practical application often requires compromise, stated Harris. This is particularly true of the ignition characteristics of fuel. Considerations of concern to the engine ignition man dictate high vapor pressure fuels. Airframe design and flight operations, on the other hand, will favor fuels of lower vapor pressure for maximum flight and crash safety. So called "safe fuels" are low vapor pressure fuels which resolve to similar ignitability characteristics as the higher vapor pressure combat fuels with changes in temperature. While it is true that lower vapor pressure fuels are not as susceptible to "flash ignition" under certain conditions, it must be realized that in local heat zones the relatively small vapor pressure differences are neutralized, and ignition can occur with either fuel. Harris suggested the drag spark areas under a crashing aircraft as an example of a local zone in which no fuel would be "safe."

Commenting on other aspects of jet fuel ignition, Harris pointed out that higher speeds of gas turbine powered aircraft are bringing in heavier fuels characterized by higher viscosities and lower vapor pressures. Any appreciable difference in viscosity will affect the droplet size of atomized fuel which will reflect as a more critical ignition characteristic.

Ram jet and rocket engine fuels for missile use have introduced extreme manufacturing controls of the variations considered normally acceptable for gas turbine aircraft applications. While ignition might require a different approach for an original design, it should not be any more difficult to sustain once it was accomplished, since it would not be required to function through the relatively greater range of gas turbine fuel tolerances.

Harris' talk was given to the Subcommittee at the Wings Club in New York City, April 4, 1957.

D. N. Harris (center) of Shell Oil Co. is pictured above with C. M. Dean (left), chairman of SAE's Ignition Research Committee, and L. R. Lentz (right), chairman of the Aircraft Gas Turbine, Ram-Jet and Rocket Engine Ignition Subcommittee of the IRC. Harris, who is manager of Aviation Products at Shell, was guest speaker at a recent meeting of the Gas Turbine Ignition Subcommittee at the Wings Club in New York City. (See story on left.)

Atwell Heads New Ordnance-Industrial Group

L. P. Atwell will be chairman of the new Ordnance and Industrial Subcomittee of SAE's Ignition Research Committee. The Subcommittee's first meeting will take place in Atlantic City during Summer Meeting, June 2–7. Atwell is assistant chief engineer in Ignition Engineering at Electric Auto-Lite Company, Toledo, Ohio.

Aero Drafting Committee Welcomes New Chairman

Former Chairman P. G. BELITSOS (right) and **Secretary L. E. TREFNY** (left) welcome **WAYNE STONE** as the new chairman of the Aeronautical Drafting Manual Committee. Belitsos was recently appointed chairman of the new Joint Aeronautical-Automotive Drawing Standards Committee. The Joint Committee was created to provide an agency for the development of drafting practices mutually acceptable to both the Aeronautical Drafting Manual Committee and the Automotive Drafting Standards Committee.

The Aeronautics Committee recently asked the aero drafting group to continue publication of drafting standards without the delays which might occur through efforts to prepare the Joint Aero-Auto Manual. The Aeronautics Committee has asked that new aero drafting standards be published using the new aero-auto format as soon as that format is finalized. In this way all future effort will be directed toward the new Joint Manual thus eliminating further revision of the Aero Manual. New format aero standards will be made available before completion of the Joint Manual.

At a dinner meeting held April 13, 1957 at the Wings Club, New York City, the Aeronautical Drafting Manual Committee presented former chairman Belitsos with a plaque in recognition of his "outstanding leadership in the field of aviation drafting standardization."

This photograph was taken during the April 3–4 meeting of the Aeronautical Drafting Manual Committee which coincided with the April 2–5 National Aeronautics Meeting held at the Hotel Commodore, New York City.

About SAE Members

Continued from page 92

ROBERT WILLIAM MARTIN has been named project engineer, plant engineering, New Departure Division, General Motors Corp. Formerly he was methods engineer, New Departure Division, GMC. In his post Martin plans and allocates all plant engineering activities for installing new equipment and material handling facilities for new integrated lines.

EDMOND J. GODIN has been appointed sales engineer, series motors, General Industries Co., Elyria, Ohio. Prior to the new position, Godin was sales engineer for Bendix Aviation Corp.'s Eclipse Machine Division at Elmira, N.Y.

RICHARD D. KELLY, vice-president of the Electric Auto-Lite Co., has been appointed director of equipment battery sales. He will serve as market coordinator in the sale of Auto-Lite batteries to customers in the automotive, marine, farm equipment, materials-handling, and aircraft industries.

GORDON S. BOYLE, previously mechanical engineer, has been made mechanical adviser for MacMillan and Bloedel Co., Ltd., B.C., Canada.

EDWARD J. GAFFNEY has joined Neodyne Corp., Elm Grove, Wis., as vice-president. This corporation was formed in March of 1956 to develop special equipment and engineering services. Gaffney was, previously, engineer, nuclear power department, Allis-Chalmers Mfg. Co.

O. A. WRIGHT has been named engineering manager of the Actuation Research Corp., Glendale, Calif. Wright has been, for the past two years, staff engineer for Missile Systems Division, Lockheed Aircraft Corp.

Wright's SAE activities include membership on Committee A-16, Aircraft Fuel and Oil Systems and Equipment; and Subcommittee A-6c, Hydraulic Pumps, Motors, and Air Compressors, both under the Aircraft Accessories and Equipment Division.

JOHN F. CREAMER, president and treasurer of Wheels, Inc., of N.Y., has been appointed to the Advisory Board for Vocational and Extension Education, N.Y. Board of Education.

RALPH H. K. CRAMER has joined the engineering department of United Air Lines, Inc., as ground equipment engineer. His previous position was that of design engineer, Wetmore Hodges & Associates, Redwood City, Calif.

Cramer is a past SAE chairman of Student Committee, Northern California Section.

LIBBUS LEWIS, formerly branch manager, White Motor Co., Albany, N.Y., is now president of the Connecticut White Truck Corp., West Haven, Conn.

JAMES C. ANTON has been appointed a field technician for Chandler-Evans Division of Pratt and Whitney Co., Inc. Previously with Bendix Products Division, Bendix Aviation Corp., as a liaison engineer, Anton has now been assigned to the west coast.

WILLIAM H. MORITZ is now automotive design engineer for Aero-Detroit, Inc., Detroit, Mich. Previously he was senior project engineer of the Truck and Coach Division, General Motors Corp., Pontiac, Mich.

W. G. SMITH is now technical officer and coordinator of special projects, Department of National Defense, London, Ont., Canada. Formerly he was located in Ottawa, Ont., Canada as technical officer.

LAWRENCE KEHOE has been named administrative engineer, structure and suspension, engineering staff, General Motors Corp. Kehoe has been with GM for more than 29 years. He joined the engineering staff in 1940, and has been in charge of the experimental shop since 1949.

WILLIAM McINTYRE will succeed Kehoe as experimental engineer. McIntyre has been with GM since 1939. He moved to the engineering staff in 1946, and has been a senior project engineer since 1953.

STEPHEN ZAND, experimental consultant, Office of the Secretary of Defense, Research and Development Board, Washington, D.C., has been named to the Advisory Council of the Gannon College School of Engineering, Erie, Pa. His appointment is for a three-year term.

Zand was SAE vice-president representing Aircraft Activity in 1940.

ROBERT L. PENCE has been named assistant managing engineer, Engineering Division, Chrysler Corp. Previously, he was a design engineer with the company. He now supervises the coordination and scheduling group of the chassis design section.

RUDOLPH H. JANSA has moved from project engineer with Studebaker-Packard Corp. to project engineer with Utica-Bend Corp., Utica, Mich.

JAMES O. TROEMNER is now development engineer, John Deere Waterloo Engineering Center, Waterloo, Iowa. He moved to this position from experimental engineer at the John Deere Dubuque Tractor Works, Deere Mfg. Co.

EDWIN C. WATSON is now with Westinghouse Electric Corp. as a staff assistant in charge of methods and economic analysis in the headquarters manufacturing laboratory located in Pittsburgh. The laboratory is engaged in design and installations of internal automation equipment.

CARLOS M. VALDIVIA, formerly layout draftsman Hall-Scott Inc., Berkeley, Calif., is now mechanical designer, Engineer Laboratory, Firestone Tire and Rubber Co., Monterey, Calif.

FRANCIS RODWELL BANKS received the 1956 Foreign Fellowship for eminence in aeronautics at the 25th annual meeting of the Institute of Aeronautical Sciences. He is a director of the Bristol Aeroplane Co., Ltd., Bristol, England, and has been with them since 1954.

CLARENCE L. JOHNSON received The Sylvanus Albert Reed Award for 1956 for "design and rapid development of high-performance subsonic and supersonic aircraft." He is vice-president—engineering and research at Lockheed Aircraft Corp. and designer of the XF-104 jet fighter.

STEWART SCOTT-HALL and **C. H. ZIMMERMAN** were awarded fellowships in the institution for 1956. They "have attained a position of distinction in aeronautics and made notable and valuable contributions in one of the aeronautical sciences or aeronautical engineering." Scott-Hall is scientific adviser, Air Ministry, England, and Zimmerman is assistant chief, Stability Research Division, Langley Aeronautical Laboratory, National Advisory Committee for Aeronautics.

EUGENE R. GAMIEL has joined Aurora Pump Division, New York Air Brake Co., as sales engineer. In his new position, he contacts major industries for pump specification, application, and sales; engineers hydraulic components and circuits for customers; and does consultation on pump application.

THOMAS B. RHINES has been named chief engineer of Hamilton Standard Division of United Aircraft Corp. Rhines joined the Research Division in 1932 and was transferred to the Hamilton Division as assistant engineer. Subsequently he served as chief production engineer, chief development engineer, and in 1951 as assistant chief engineer.

JOHN J. HOSPERS has been cited by the Dallas, Tex., Chamber of Commerce at a special "Jack Hospers Day" luncheon as "an outstanding asset to

his city." Hospers is the special assistant to the president of Chance Vought Aircraft, Inc., Dallas.

N. R. BROWNYER, vice-president of Timken-Detroit Axle Division, Rockwell Spring and Axle Co., has been appointed director of engineering of the Axle Division. He will be responsible for central design operations, service engineering, and the coordination of all division engineering activities.

STANLEY WALLACE has been appointed to the position of representative in Canada of Vinco Corp., Detroit.

JAMES K. DICKEY is now sales representative for Rotary Seal Division, Muskegon Piston Ring Co., Chicago. His previous position was district manager, National Seal Division, Federal-Mogul-Bower Bearings, Inc., also of Chicago.

JEROME OSCAR FELDMAN is now engineer, supervising administration of reliability control, Arma Division of American Bosch Arma Corp. Prior to this position, Feldman was production specialist, U.S. Air Force, working on "SAGE" Air Defense System.

DR. WILLIAM F. BALLHAUS has been elected vice-president and chief engineer of Northrop Division of Northrop Aircraft, Inc., Hawthorne, Calif. This is a newly established division, combining the Hawthorne operations and related aircraft and missile facilities. He was formerly chief engineer, Northrop Aircraft, Inc., Northrop Field.

DR. LESTER M. GOLDSMITH, general manager of engineering and construction, Atlantic Refining Co., has recently been cited by the Pennsylvania Society of Professional Engineers in cooperation with other affiliated engineering societies, as the Philadelphia Engineer of the Year.

Goldsmith was praised for "his outstanding contributions to the Advancement of the Petroleum Industry, the Engineering Profession, and in the service of his country."

LIONEL D. THOMPSON has joined Utica-Bend Corp., subsidiary of Curtiss-Wright Corp., as product engineer, large engines, where he is responsible for design and development of large high output, lightweight diesels. Formerly Thompson was product engineer, large engines, Studebaker-Packard Corp.

He was a member of the SAE Diesel Activity Committee from 1954 to 1956 and was vice-chairman of the committee in 1955.

GLEN H. HOLZHAUSEN has joined Douglas Aircraft Co., Inc., Santa Monica, Calif., as design engineer. Prior to his new position, he was design engineer at McColloch Motors Corp., Los Angeles.

RUSSELL A. BLANCHARD, formerly general sales manager, has been named vice-president of Extruded Metals Division operations at Detroit Gasket and Mfg. Co.

WILLIAM CLAY FORD, vice-president of Ford Motor Co., has been designated vice-president in charge of product planning and styling.

HENRY FORD II has been named recipient of the ninth annual Rerum Novarum medal of St. Peter's College.

He has also received the Grand Band Degree of the Order of the Star of Africa from the Ambassador of Liberia. The African Republic honored Ford for "his contributions to human welfare and his interest in Liberia."

ERNEST V. SMUTEK has been named sales engineer of Detroit Harvester Co. He was with F. J. Jacobs Co., before joining Detroit Harvester.

ROBERT P. LINDEMAN, formerly chief automotive engineer of the Twin Cities Division, Minneapolis, Minn., Standard Oil Co. of Indiana, has been made chief automotive engineer in the St. Louis, Mo., branch of Standard Oil.

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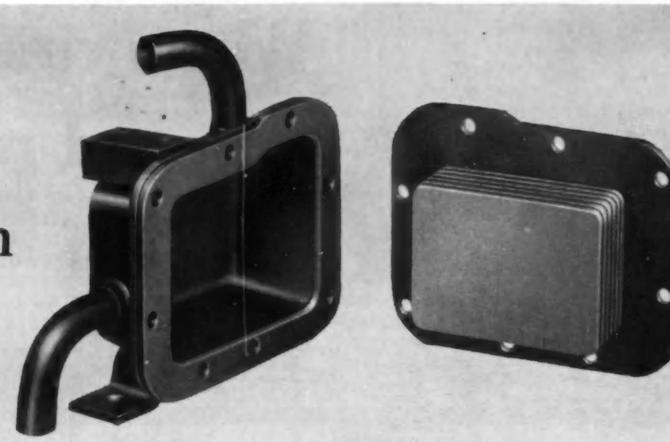
Better Engine Operation with Oil Coolers



Heat dissipation in limited area accelerated by new, plate-type unit

The ever higher performance being built into modern engines is creating new problems in heat dissipation. Engine efficiency, pressures and operating speeds have increased. So have operating temperatures of the engine parts. But the surfaces and area available for dissipating heat may be unchanged or even smaller. Therefore, more heat is drawn into the lubricating oil of the engine.

Although friction losses in percent of total power output are dropping, the absolute rate of heat generated has gone up. This heat may exceed temperatures which the bearings are designed to resist and may rise to destructive levels.

In commercial vehicle, marine and industrial engines, heavy work loads are usually frequent or constant enough to require an oil cooler to maintain viscosity and to augment heat rejection. Such a unit may be attached to the engine or built into the engine block.

LARGE CAPACITY IN SMALL UNIT

To facilitate concentrated heat dissipation in a small space, Long Manufacturing Division of Borg-Warner Corporation has developed a compact, plate-type heat exchanger with large heat rejection capacity for its size. The unit is applicable on or in any engine requiring lubricant cooling. Current applications extend to 400 btu/pm. The element's rectangular shape is proportioned to be readily adaptable to a small aperature in the block where water can be circulated.

The Long engine oil cooler, installed here on a new marine engine, is small, unobtrusive, easily accessible.

It can also be used for any oil cooling application, such as in transmissions, torque converters and hydraulic presses.

The high efficiency of this cooling element lies in the diagonal flow path of the oil across the plates, utilizing the maximum possible length of the unit. Location of the fittings gives high velocity turbulence and effective oil distribution.

Spacers are placed between the plates to allow free circulation of the cooling water around this core. The assembly is then brazed into an integral structure. Counterflow paths of the oil and water assure maximum heat exchange efficiency.

The turbulators are designed to minimize the pressure drop across the plates. Ingenuity in designing flow paths and stack arrangements of a single design element, according to the operating requirements, contributes to the economy of the unit. Any reasonable number of plates may be assembled in parallel, in series, and in parallel series.

RUGGEDNESS AT LOW COST

Manufacturing the casing (in accessory applications) from steel stampings instead of fabricating it from castings is a unique, cost and weight saving feature. Paint protects the exterior while the waterside is clad with rust- and corrosion-resistant cupronickel. The plate shells enclosing the mild steel turbulators are formed from stampings of solid cupronickel.

On the waterside this heat exchanger may be readily cleaned and the multiple-plate core can be removed from the casing without disturbing the water connections.

Traditional Long engineering and craftsmanship assures the quality, efficiency and dependability of this oil cooler. It is the first in a series of new products from this 53-year old manufacturer of heat exchangers, clutches and torque converters.

An engineering bulletin, including basic heat transfer and pressure drop charts from performance tests at Long Laboratories, may be had on request. The data also lists information requirements for obtaining recommendations on specific applications of this and other types of oil coolers.

Write to Dept. OC 1, Long Manufacturing Division, Borg-Warner Corp., 12501 Dequindre Street, Detroit 12, Michigan. In Canada: Long Manufacturing Company Limited, Oakville, Ontario. Export Sales: Borg-Warner International, 36 South Wabash Street, Chicago 3, Illinois.

About SAE Members

Continued from page 112

PHILIP W. SKOVE is now with The Nash Engineering Co., South Norwalk, Conn., working with sales administration. Prior to this position he was with the New York Air Brake Co.

ALFRED GOLDBERG has recently returned from Tel Aviv, Israel, after a tour of 20 months' duty. Goldberg has joined Long Beach Aeromotive, Inc., as vice-president and general manager.

W. PALMER LANAGAN and **GEORGE W. REED** have been appointed territorial selling agents for Du Mont's TV-Type EnginScope. Lanagan is responsible for Florida and Georgia, and Reed covers eastern Pennsylvania, western New Jersey, Delaware, Maryland, and the District of Columbia. The new TV-Type EnginScope was released to the automotive industry in 1956 and is used to pinpoint automotive engine faults by displaying the trouble in the form of patterns of light on the tv-like screen.

HAROLD D. CONNELLY has joined International Harvester Co. as sales engineer. Prior to this position he was fleet engineer, Berman Service, Inc., Allentown, Pa.

H. C. MEAD, formerly assistant chief engineer, is now chief engineer in the engineering department, Guide Lamp Division, General Motors Corp. **R. N. FALGE,** previously chief engineer of the division, is now technical assistant to the general manager. **G. W. ONKSEN,** formerly research engineer for the division, is now engineering head, research and development, at Guide Lamp.

JAMES KNOWLES, formerly chief product engineer, Ford Motor Co., has been named chief transmission engineer of Ford's transmission and axle group.

BAIN GRIFFITH, formerly standard transmission and axle engineering manager at Ford, has been named chief axle and chassis components engineer for the company.

RICHARD W. FULTON has retired from Gulf Oil Corp. after 20 years of service, as a T.B.A. marketer, to enter into ownership and operation of a wholesale selling business of Gulf T.B.A. products to service stations.

BELDING H. McCURDY has joined Cargill-Detroit Corp. as chief engineer. He now has complete charge of engineering and estimating design and development of all products and systems. Prior to joining Cargill-Detroit, he was executive engineer and director of Hancock Mfg. Co., Jackson, Mich.

SIDNEY C. PALMER has transferred from general manager, sales and service department, Aviation Gas Turbine Division, Westinghouse Electric Corp. Kansas City, Mo., to New York City as area manager of the marine and transportation activity.

MILO M. DEAN, formerly assistant control manager, Mercury Division, Ford Motor Co., has been named manager of the quality control department of Ford.

JOHN BENNETT REA, formerly supervisor of service training, Ford Motor Co. of Canada, Ltd., has been made assistant to the mechanical superintendent of Sprostons (Jamaica) Ltd., Kingston, Jamaica, B.W.I.

CHARLES STEWART MOTT, a General Motors Corp. director, has been chosen as Michigan engineer of the year at an inter-society dinner held on February 21, in the SAE Mid-Michigan Section. He was cited for

his "outstanding contributions in building a better community. He has 'created' a model community school concept; 'designed' a renowned adult educational program; 'developed' a model junior college; and 'engineered' a big segment of the new four-year college."

ROGER POCOCK has been transferred to Cummins Engineering Co.'s new plant in Scotland. Prior to his relocation, he was automotive application engineer, Cummins Engineering Co., Columbus, Ind.

Pocock has served as field editor for SAE Journal in the Indiana Section.

WILLIAM H. BACON, has been appointed group leader, knock testing, at Tidewater Oil Co.'s Delaware Refinery. He has previously been group leader in the automotive laboratory in Delaware.

C. A. NICHOLS has been appointed technical assistant to the vice-president in charge of process development staff of General Motors Corp. He joined the GM Technical Center from Delco-Remy Division, Anderson, Ind., where he was director of manufacturing facilities.

At the annual shareholder's meeting of Minneapolis-Moline Co., the following three SAE members were elected to the board of directors: **VOLLMER W. FRIES, WARREN C. MacFARLANE**, and **WAYNE H. MacFARLANE.**

ARTHUR A. AYMAR is now with AiResearch Mfg. Co., Garrett Corp., Phoenix, Ariz., in preliminary design. Previously he was senior project engineer, Stratos Division, Fairchild Engine and Aircraft Corp.

Aymar was SAE vice-chairman for Aeronautics of Metropolitan Section for 1956–1957. His resignation was caused by relocation.

JERRY J. TABOREK has been named project engineer—research and development, Phillips Petroleum Co., Bartlesville, Okla. His previous position was development engineer, Tow Motor Corp., Cleveland.

J. GARRETT FORSYTHE, JR. has joined Turbomotor Division, Curtiss-Wright Corp., as analytical engineer. Previously he was project engineer, Scott Paper Co., Chester, Pa. In his new position he works with design and stress analysis of gears and gear boxes used in aviation gas turbines and other mechanical devices.

RONALD E. TRENKER is now with General Electric Co. of Utica, N. Y. in the Light Military Electronic Division.

DONALD H. MONSON, formerly chief engineer at the Kenosha plant of American Motors Corp., has been named to the newly created position of manufacturing engineer.

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About SAE Members

Continued from page 116

GORDON M. BUEHRIG, previously station wagon planning manager of Ford Division, Ford Motor Co., is now with Ford Advanced Car Engineering.

He is an active member of SAE, having served on the SAE Body Activity Committee for the last six years. In 1954 he was SAE vice-president representing Body Activity and is now Membership vice-chairman for that committee.

THOMAS E. RICHARD has been made engineering section manager, Air Associates, Inc., Teterboro, N.J. Previously he was supervisor of mechanical engineering at Air Associates.

EDWARD J. SULLIVAN has joined Lincoln Division of Ford Motor Co. as retail merchandising manager at the Kansas City district sales office.

A comprehensive study of the mechanics of vehicle mobility, the "Theory of Land Locomotion," has been written by **LT.-COL. M. G. BEKKER**, Technical Director of the Land Locomotion Research Laboratory, Department of the Army. The book undertakes to give a more accurate knowledge of the process in which a vehicle affects the physical medium through which it operates and the way in which the medium, in turn, affects the design or use of the vehicle.

Placing particular emphasis on off-the-road vehicles, the book discusses in detail problems of soil and snow mechanics; size-form relationships as an index of economy; terrain conditions; the process of moving tracks, skis, sleds, toboggans, rigid wheels, and pneumatic tires; static and dynamic behavior; and dimensional analysis, testing, and overall economy.

Published at $12.50 by the University of Michigan Press, Ann Arbor, Mich., the book is being used as a textbook for two new graduate courses in automotive engineering which Bekker and **PROF. E. T. VINCENT**, chairman of the Department of Mechanical Engineering, University of Michigan, are teaching at the university.

A. O. MALONEY is the new plant manager of Chrysler Corp.'s Lynch Road plant. Prior to this post he had been factory manager since 1952. He joined Chrysler in 1948 as a student at the Chrysler Institute of Engineering and was made chief metallurgist at Lynch Road in 1943.

SUMNER E. CAMPBELL is now director of research, Macmillan Petroleum Corp., Los Angeles. He has been associated with Macmillan for 21 years, interrupted by an extended absence as director of research and development, Palomar Oil and Refining Corp., Bakersfield, Calif.

HOWARD N. CLARK is now sales engineering representative in western N.Y. state. The companies which he represents are: Beemer Engineering Co., New England Spring Mfg. Co., Industrial Retaining Ring Co., Fasteners, Inc., and Thompson-Bremer & Co.

Clark organized the SAE Rochester Division, Buffalo Section, in 1953 and was first regional vice-chairman for Rochester.

JAMES E. MURPHY of Chrysler Corp. has been named coordinator of sales for the divisions in the N.Y. zone. He joined Chrysler in 1947 and was Eastern zone manager for Dodge for two years.

JACK C. BASSIE is now supervisor, mechanical design operation, controls section, Aircraft Gas Turbine Division, General Electric Co. His previous position was supervisor, controls and accessory section, gas turbine department, Ford Motor Co.

JOHN G. McNAB has been appointed coordinator of petroleum products and medical research at Esso Research and Engineering Co. Previously McNab was deputy coordinator for the company.

RICHARD T. AGSTER has been named president of Petroleum Packers, Inc. Prior to this position he was manager, petroleum department, United Co-Operatives Inc., Alliance, Ohio.

ALFRED B. RODE, previously design draftsman at the Longueuil Plant, Quebec, Canada, Canadian Car and Foundry Co., Ltd., has been made a designer with the company.

JAMES R. HARRISON has been given new responsibilities in the Michigan sales department of the Valve Division of Eaton Mfg. Co., Cleveland. Previously he was assistant sales manager of the Saginaw Division.

L. H. DIEHL, JR., a vice-president and director, will head the Automotive Division operations, Detroit Gasket and Mfg. Co.

D. WOLKOV is now employed as chief engineer for Midwestern Instruments, Tulsa, Okla. Formerly he was chief engineer, Superior Magneto Corp., Long Island City, N. Y.

WILLIAM HOWARD McCOY has retired from senior partnership in the McCoy-Melling Engineering Co. of Ferndale, Mich.

RICHARD G. RUFFE has joined the Convair Astronautics Base, Fla. as test engineer. He was previously test engineer at Ford Motor Co.

JOEL WARREN MAXEY, past assistant supervisor, plant engineering section of Ford Motor Co., has become superintendent, powerplant, building services, piping, plumbing, and hydraulics at Ford Motor Co.'s Research and Engineering Center.

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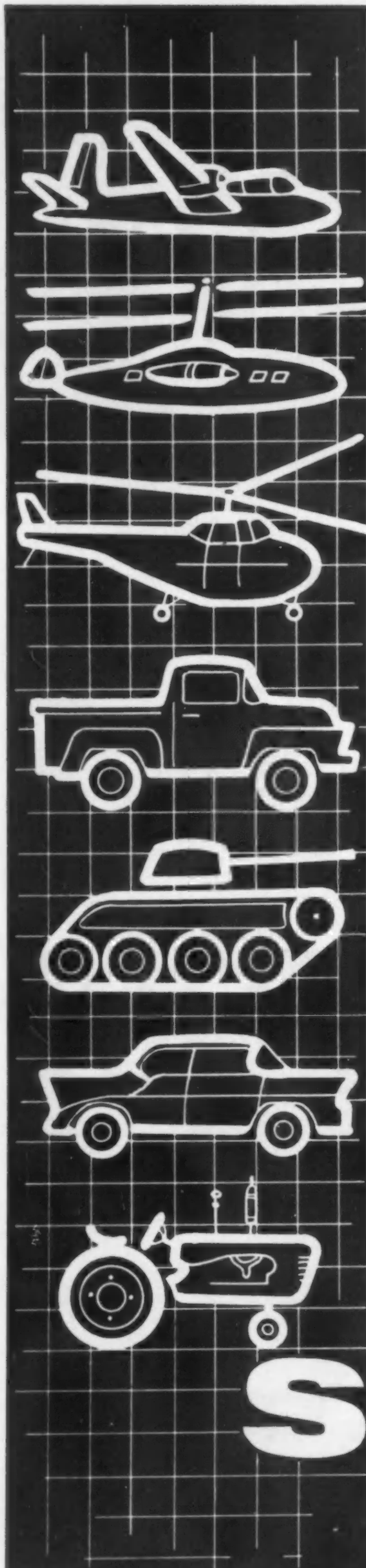

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A multiple point, low-pressure, timed, speed-density injection system, Simmonds SU Fuel Injection offers these proven advantages: it overcomes major icing problems to give improved cold starts; it eliminates the need of hot-spots and pre-heaters and simplifies manifold ducting; it provides increased power output due to removal of intake obstructions. The Simmonds System also provides improved fuel distribution and better cylinder head cooling – its operation is not affected by engine attitude.

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Obituaries

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ELVERTON W. WEAVER

Elverton W. Weaver, member of SAE for 46 years, died November 12 in Cleveland Heights, Ohio.

Weaver was born in 1880 and became a member of SAE in 1910 when the Society was only five years old. Between 1904 and 1908, he worked as draftsman and designer in various New York motor car companies until joining Peerless Motor Car Co. of Cleveland as designer. He worked at Peerless until 1914 when he became consulting engineer, Weaver and Kemble, Cleveland.

In 1926, Weaver was made chief engineer, automotive department, George T. Trundle, Jr., Engineering Co., Cleveland. From 1932 to 1937 he was automotive engineer for Ferro Machinery and Foundry Co., and then returned to Trundle Engineering Co. as automotive engineer. In 1940 he became construction engineer at the Towmotor Co., Cleveland, and remained there until retirement in 1951.

CARL B. PARSONS

Carl B. Parsons, 72, president of the Parsons Co. of Detroit, died Dec. 21, 1956. He had been a member of SAE since 1925 and had served as vice-president representing Passenger Car Body Engineering in 1931.

Parsons came to this country from Sweden at the age of 16 and was graduated from the Andrew F. Johnson School of Body Design. He served his apprenticeship as a body builder at Kimball's in Chicago and later organized the Standard Limousine Co.

He was given credit by the Old Timers Club for producing the first closed sedan passenger-car body which was delivered in 1910 mounted on a Marion chassis. During the next few years he held the position of chief body engineer at Mitchell (later Nash), Cadillac, and Studebaker.

In 1912 he founded the Parsons Mfg. Co. and after 12 years of successful operation this business was purchased by Motor Products Corp. where Parsons joined the staff. In 1928 he formed the Parsons Corp.

In addition to his membership in SAE, Parsons held membership in the Old Timers Club, the Engineering Society of Detroit, and the American Society of Body Engineers.

LAWRENCE DALE BELL

Lawrence D. Bell, president of Bell Aircraft Corp., died October 20.

Bell was born in 1894 in Indiana and became a mechanic for his brother, Grover E. Bell, and Lincoln Beachey, exhibition fliers, in 1912. In 1915 he joined Glenn L. Martin Co., Los Angeles, as shop mechanic. He was later named general superintendent of the Santa Monica plant and subsequently managed the Cleveland plant. During this time he was vice-president and general manager of Glenn L. Martin.

In 1928 he was named general sales manager of Consolidated Aircraft Corp. of Buffalo, N. Y., and vice-president and general manager in 1929. In 1935 Bell and associates organized the Bell Aircraft Corp. of Buffalo.

Bell had served as president of War Production Council, East Coast, Inc., and National Aircraft War Production Council. He was chairman of the board of W. J. Schornberger Co., Cleveland, and Erie Insurance Co. He had been a director of Irving Airchute Co., Niagara Share Corp., and on the board of governors for Aircraft Industries Association.

Bell joined SAE in 1918 and received the Daniel Guggenheim Medal in 1944 for achievements in building military planes and contributions to plant production methods.

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VERSATILE

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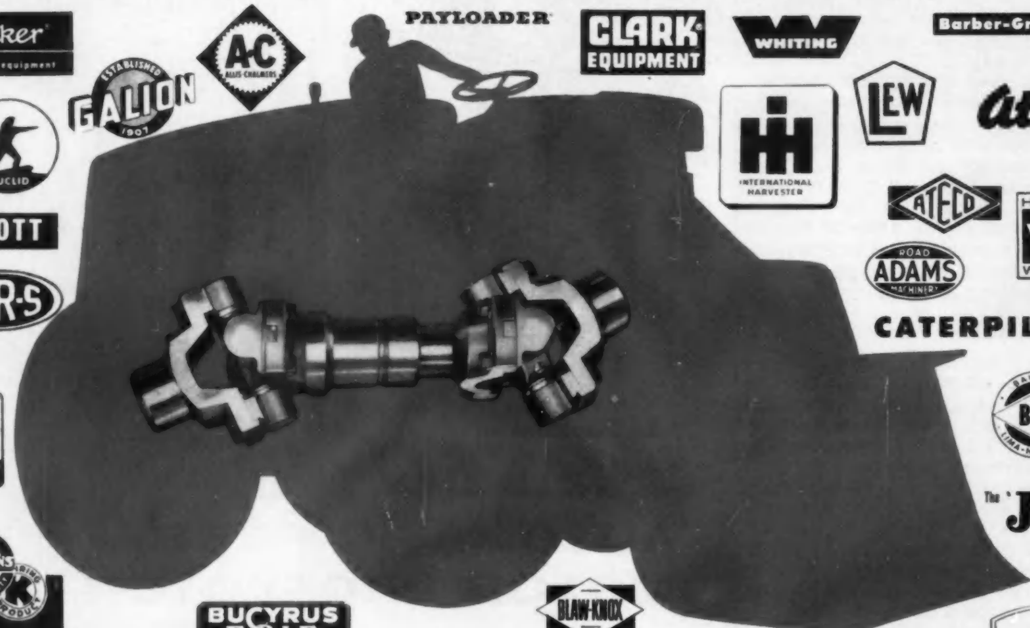

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Obituaries

Continued from page 123

BYRON E. SNOW

Byron E. Snow, director of sales, original equipment, Hoover Ball and Bearing Co., died Aug. 30, 1956.

Prior to joining Hoover Ball and Bearing, he had been serving since 1953 as manager, Chicago office, Aeroquip Corp.

Snow was educated at the University of Michigan and began in industry in 1928 as an interior architectural design assistant with Donald Caniard, Jackson, Mich.

Two years later he became assistant to the pipe line superintendent at Consumers Power Co. in Jackson.

In 1933 he formed the Byron Snow Studios, an interior and architectural design firm, which he operated for 10 years.

In 1943 he joined Aeroquip Corp. as a sales engineer and subsequently served as a company representative. Three years later he became general manager and senior partner, Aeroquip Sales and Engineering, Ltd.

In 1949 Snow was named vice-president and general sales manager, Aeroquip Sales and Engineering, Inc.

E. O. DIXON

E. O. Dixon, vice-president in charge of research and metallurgy, Ladish Co., died on Nov. 4, 1956. He was a member of the SAE Engineering Materials Activity Committee and Iron and Steel Technical Committee Division 2.

Dixon attended Crane College in Chicago and the University of Illinois where he studied chemical engineering.

In 1919 he joined International Harvester Co. as a junior metallurgist. Two years later he was made heat treatment foreman for the company and in 1923 he was named chief metallurgist.

Five years later Dixon joined Ladish Co., which was then Ladish Drop Forge Co., as chief metallurgist. He was named vice-president in charge of research and metallurgy in 1952.

KENNETH W. HILDENBRAND

Kenneth W. Hildenbrand, chief inspector, Monroe Auto Equipment Co., Monroe, Mich., died on March 1.

Hildenbrand was born in 1898 and attended the Drexel Institute in 1917 and 1918. In 1922 he became an assistant in the engineering department of the Philadelphia and Reading Railway Co., and subsequently factory representative and Detroit branch manager of the John Warren Watson Co., Philadelphia. He served as Detroit manager from 1929 until 1935 when he became factory manager of Watson Co. and remained in this position until 1943. At this time he became chief inspector for the Monroe Auto Equipment Co.

Hildenbrand joined SAE in 1933.

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Obituaries

Continued from page 125

DEWEY H. CAMPBELL

Dewey H. Campbell, chief engineer, P & G Mfg. Co., Portland, Ore., died on July 17, 1956.

With only a grammar school education, Campbell started in industry learning both the mechanic and the machinist trades by apprenticeship.

In 1936 he joined Harold Blake Construction Co. in Portland, Ore., as a master mechanic. Two years later he organized the Winterset Welding and Machine Works in Winterset, Iowa, which he operated until 1942. His next four years were spent as welding instructor with Commercial Iron Works and Northwest Marine Iron both in Portland.

Following this he formed Campbell's Diesel Service at Newport, Ore., where he was a General Motors Corp. dealer in marine and industrial engines, covering both sales and service. It was at this time that he invented his "valve gapper," a tool which checks valve gap on overhead valves with dial indicator.

Campbell joined P & G Mfg. Co. in 1953 as director of research and subsequently served as research and development manager and chief engineer.

J. ALLAN MAHONEY

J. Allan Mahoney, sales engineer, Hercules Motor Corp., Canton, Ohio, died February 19.

Mahoney was born in 1891 and started working in 1912 as an apprentice for Allis-Chalmers Mfg. Co., Milwaukee, Wis. He later was named foreman and special representative for Allis-Chalmers, and, in 1920, branch manager until 1924. He then joined Ford Motor Co. as a field representative, and, from 1925 to 1928, was engineer for Vacuum Oil Co. of Milwaukee, Wis.

In 1930, when he joined SAE, he was sales engineer, Waukesha Motor Co., Waukesha, Wis., where he served until 1943. Mahoney became division manager and subsequently sales manager of the Climax Engineering Co., Clinton, Iowa, serving with them from 1943 until 1946.

He was then named sales engineer of the Hercules Motor Corp. of Canton.

GEORGE J. HAUSAMANN

George J. Hausamann, staff engineer, engineering and sales, Eclipse-Pioneer Division, Bendix Aviation Corp., died January 11. He had been with Eclipse since 1922 when it was Eclipse Machine Co.

Hausamann was born in 1888 in Constance, Germany, and received a B.S. degree in electrical engineering from Cooper Union Institute in 1915.

He began in industry in 1905 with the I.R.T. Co. of New York and in 1907 was made foreman with the Cross Electrical Co. in Hoboken, N.J.

Hausamann was made chief electrician for the Knickerbocker Hotel in 1910 and from 1913 until 1922 he was general foreman and service engineer with Bijur Motor Appliance Co. in Hoboken.

ROBERT J. WOODS

Robert J. Woods, aircraft design consultant, Bell Aircraft Corp., and SAE vice-president representing Aircraft Activity in 1951, died in November, 1956.

Following graduation from the University of Michigan in 1928, Woods joined the National Advisory Committee for Aeronautics as an aircraft research engineer. The next year he spent as an engineer in aircraft design with Towle Aircraft Corp. and the following year he worked as a project engineer with the Detroit Aircraft Corp.

Two years later he joined Lockheed Aircraft Corp. as a project engineer and in 1933 he transferred to Consolidated Aircraft Co.

Woods joined Bell Aircraft in 1935 as director and chief design engineer, and served in that capacity until 1954 when he became a consultant for Bell.

LAWSON H. FREW

Lawson H. Frew, senior staff engineer, Shell Oil Co., died January 31.

Frew was born in 1909 in Indiana and graduated from Purdue University in 1933 with a B.S. in chemical engineering. From 1939 to 1942 he was layout engineer at Continental Can Co., Inc., Milwaukee. He then joined Chrysler Corp. in the DeSoto Division as project engineer.

In 1945 he became staff engineer and subsequently senior staff engineer, Shell Oil Co.

RICHARD C. LONG

Richard C. Long, manufacturers' representative, Truck Equipment Co., died March 13.

Long, who was a member of SAE since 1932, had served as Metropolitan Section chairman in 1948-1949.

From 1922 to 1933 Long was sales manager with Wheels, Inc. He was made manager of the company in 1934. The following year he was named vice-president of the firm.

In 1943 he joined Warner Electric Brake Mfg. Co. which later became Warner Electric Brake and Clutch Co. Long was made district manager for Warner Electric in 1953, and held that position until joining Truck Equipment Co. in 1956.

EDWARD R. HEWITT

Edward R. Hewitt, 91, author and one of the pioneers of the automotive industry, died on February 19.

Hewitt attended Princeton University and the University of Berlin before launching into the automotive field.

Early in the century, he designed a one-cylinder automobile, which he marketed in England before he founded the Hewitt Motor Car Co. in New York.

Hewitt then designed the motor which was used in the Mack truck. Following this, his company's assets

were acquired by the International Motor Corp. which manufactured Mack Trucks, and he served on its board of directors.

In addition to his automotive interests, Hewitt, was an avid fisherman and authored several books on the subject. One of his books, "Days from Seventy-five to Ninety," was published in January of this year.

Hewitt also served as treasurer of the Cooper Union from 1898 to 1924.

JOSEPH H. STALEY

Joseph H. Staley, Columbus, Ind., manufacturer and inventor and SAE member since 1917, died in November, 1956.

Staley, who was in semi-retirement for the past 15 years, held some 40 patents on automotive and electrical inventions.

He started in industry as factory superintendent with Martindale and Millikan Co. in Franklin, Ind., in 1914. The following year he purchased the firm and organized the Continental Auto Parts Co., a company which designed and built special cars and trucks. In 1919 he moved the business to Columbus and in 1930 the name of the firm was changed to Staley Mfg. Co.

In 1937 Staley organized the Electric Switch Corp. to manufacture mercury switches and sequence controls. He remained president of this firm even during his semi-retirement.

WILLIAM NITTEL

William Nittel, assistant chief engineer of the Foreign Licensee Division of Purolator Products, Inc., Rahway, N. J., died Dec. 13, 1956.

Nittel had been affiliated with the Purolator firm for six years. Prior to joining the company, he was an engineer with the Billiton Co. of Holland.

He formerly was superintendent and general manager of a Billiton aluminum rolling mill in Java, superintendent of a tinning process mill in Texas City, Tex., and former assistant to the chief mining equipment engineer at Billiton's New York City outlet.

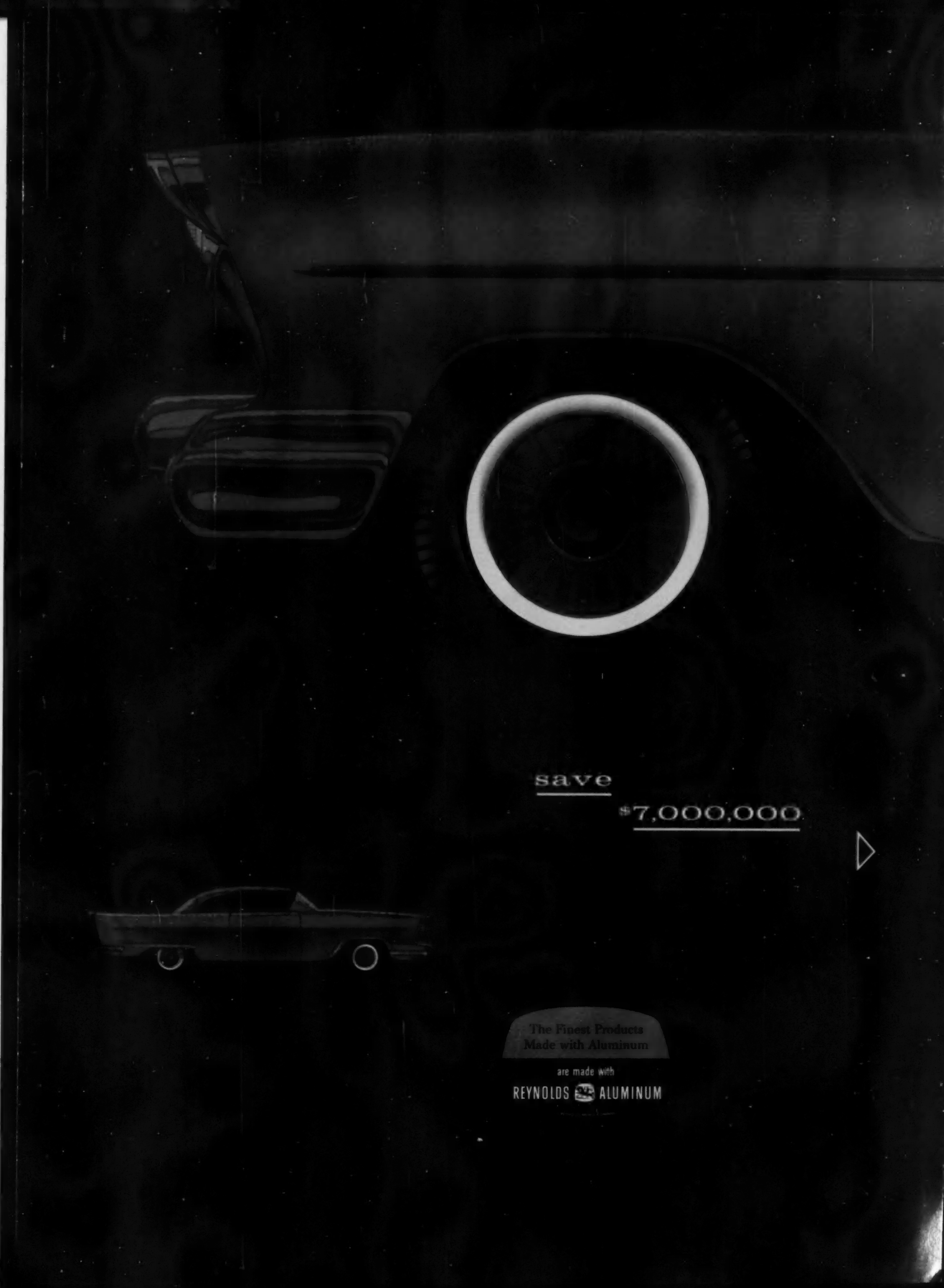
Nittel was born in Djakarta, Indonesia, and studied mechanical, electrical, and chemical engineering at the Christel Lyceum, Hilversum, Holland. He attended the Middelbaar Techniscat at Amsterdam and furthered his engineering education at schools in Germany and Switzerland.

DUNCAN P. FORBES

Duncan P. Forbes, chairman of the board, Gunite Foundries Corp., Rockford, Ill., and SAE member since 1928, died in February.

Forbes was born in 1896, attended the Hill School, Pottstown, Pa., and was graduated from Yale University in 1919. From 1920 until 1928 he was works manager and subsequently vice-president of Rockford Malleable Iron Works Corp. This later became the Gunite Foundries Corp. of which Forbes was president from 1930 to 1955 when he became chairman of the board.

continued on page 131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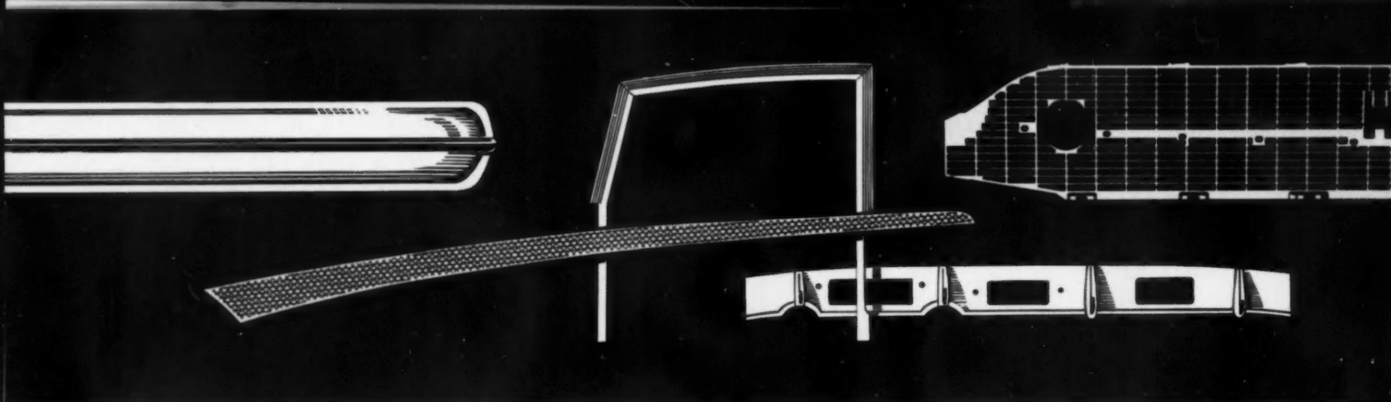

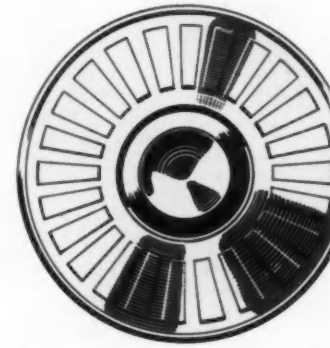

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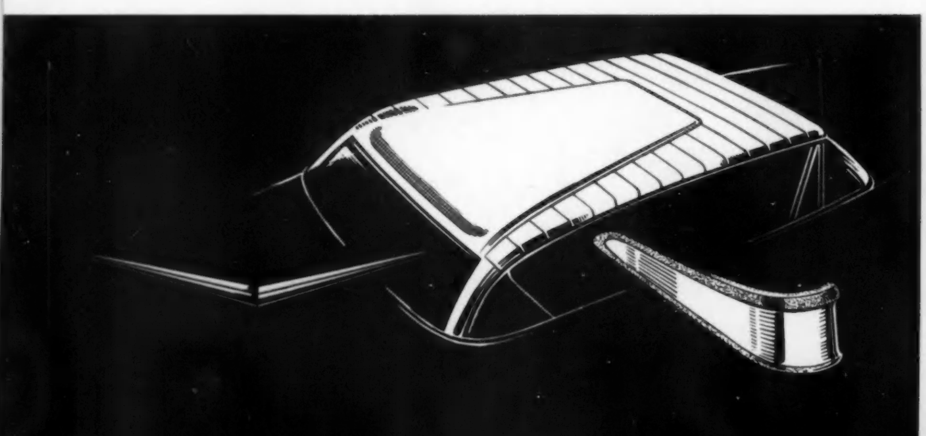

The Finest Products Made with Aluminum

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REYNOLDS ALUMINUM

Obituaries

Continued from page 128

CHANNING E. HARWOOD

Channing E. Harwood, member of SAE since 1934, died Dec. 29, 1956.

Harwood was born in 1894 and graduated from Dartmouth College in 1915. He joined the Russell Mfg. Co., Middletown, Conn., where he worked as salesman, assistant overseer, assistant to the general manager, and research manager from 1933 until 1936. He was then named sales manager, director, resident, and subsequently manager, in 1943, of the Aero and Automotive Division, Russell Mfg. Co.

In 1946 Harwood became an SAE member with reserve member status.

FRANK T. ARMSTRONG

Frank T. Armstrong, Detroit automotive regional engineer for the Wagner Electric Corp. until his retirement in July 1956, died on Jan. 15.

He had been with the company for 35 years.

Armstrong was graduated from Armour Institute and was connected with the Remy Electric Co. until joining Wagner Electric in 1918.

He had been a member of SAE since 1919 and also was a member of the Engineering Society of Detroit.

RAY L. HOWARD

Ray L. Howard, veteran of the automotive and aviation industries and since 1950 a sales engineer for Dana Corp., died on Jan. 29.

Prior to becoming a clutch specialist in the automotive industry, he had an interesting career in aviation. He barnstormed with Capt. Edward Rickenbacker, immediately after World War I, and also served as a test pilot for Fokker Aircraft Co.

He also accompanied Sir Hubert Wilkins on the latter's attempt to fly over the North Pole in 1926.

While active in aviation, Howard became interested in automobile racing and drove in the Indianapolis Speedway classic in 1919, 1920, and 1921.

Howard became widely known in the automotive industry through his work with clutch units and friction materials, first with Cleveland Graphite Bronze Co., then with the Auburn Clutch Co., of Auburn, Ind., which was purchased by Dana Corp. in 1947.

OSCAR L. MAAG

Oscar L. Maag, consulting engineer with Timken Roller Bearing Co. and a member of the SAE Fuels and Lubricants Technical Committee, died on Aug. 22, 1956.

Maag received both B. S. and M. S. degrees from the University of Kansas and in 1916 he joined Kansas City Testing Laboratory as chief chemist, commercial testing. The following year he was with the U. S. Bureau of Standards at the Pittsburgh Arsenal.

In 1923 he joined Galena Signal Oil Co. as assistant chief chemist, and in 1938 he moved to Timken.

RANDOLPH B. BURBANK

Randolph B. Burbank, assistant engineer, Marquardt Aircraft Co., Van Nuys, Calif., died recently.

Burbank was born in 1927 in Los Angeles and was graduated from West Coast University in 1954 with a B.S. in mechanical engineering.

In 1947 he worked on Aviation maintenance at Van Nuys as a mechanic and subsequently became an assembler, first with North American Corp., Inglewood, Calif., and later, 1948 to 1951, with Lockheed Aircraft Co. In 1954 he joined Marquardt as an engineer aide and later was made assistant engineer.

ELMER LATSHAW

Elmer Latshaw, mechanical engineer, Department of Navy, Naval Air Material Center, Philadelphia, died January 18.

Latshaw was born in 1894 and started working in 1919 as draftsman, J. G. Brill Co., Philadelphia. He was made, in 1926, railway truck engineer, and later technical engineer in 1940 for ACF-Brill Motors Co. where he served until 1955. At this time he became mechanical engineer for the Navy Department.

Latshaw became a member of SAE in 1946.

A. LAMONT FARNSWORTH

A. Lamont Farnsworth, field supervisor, Transportation Division, Quality Bakers of America, died Dec. 22 in Danville, Ill.

Farnsworth was born in 1901 and started working in Danville as a mechanic and helper, later becoming head mechanic for the Ford Sales and Service dealer in Belleville, N. J.

From 1927 to 1931 Farnsworth was a salesman and service man for Atmo Fire Protection. He later joined Kings County Buick, Brooklyn, N. Y., where he served from 1931 to 1943 as foreman; new car service manager; and machine shop foreman.

He then joined Air Reduction Sales Co., N. Y., as assistant motor truck supervisor and in 1947 became service foreman and subsequently service manager at Joehn Motors, Danville.

In 1952 Farnsworth joined Quality Bakers of America as field representative in the Transportation Division.

Briefs of SAE PAPERS (continued)

11 p. Description of seal test rig devised to provide fast rough screening test for materials that might be used for rubbing seals in aircraft gas turbine, to permit use of easily procured test pieces, and to determine dry load carrying capacity of pairs of materials, approximate wear rates, temperature limitations, and most compatible mating surfaces, etc; preparation of test pieces, procedure and results; materials used.

Concept, Design, and Manufacture of Supersonic Aircraft, F. W. DAVIS. Presented Jan., 1957, 9 p. Problems arising out of technological race between United States and Russia in aircraft production; Russians progress from idea to product faster; possibilities for improving American methods by simplification of product, its requirements or management task; facilitation of design by use of IBM computers; example of methods used in Convair's B-58 production program.

Flight Testing and Flying Techniques of High Altitude Supersonic Aircraft, A. W. LeVIER. Presented Jan., 1957, 11 p. Account of some of test pilot's experiences in flying over 110 different types of aircraft including Lockheed fighter P-38, Lockheed jet fighter XF-80A and F-104A Starfighter; implications for improved design of jet aircraft flying under extremes of temperature, altitude, and speed.

DRAFTING PRACTICE

Development and Use of Graphic Illustrations in Product Engineering, F. JANTZ. Presented Jan., 1957, 11 p. Graphic illustration is perspective drawing in any given scale based on technical information emanating from idea, orthographic engineering drawing or completed product; its usage and demand in automotive field and other applications; how graphic illustrations are made.

FUELS & LUBRICANTS

Some Fuel Characteristics Which Affect Diesel-Engine Economy, J. M. SILLS, W. A. HOWE. Presented Jan., 1957, 43 p. Results of cooperative investigation by Greyhound Corp. and Gulf Oil Corp. to determine quality characteristics of diesel fuels and maintenance factors of engine in effort to minimize exhaust smoke; equipment, fuels, and procedure used in economy tests; results; charts, and data.

169,000,000 Bus Miles in Chicago with LPG, S. D. FORSYTHE. Presented Jan., 1957, 6 p. Six years' experience of Chicago Transit Authority with fleet operation of 1050 LPG-fueled at six dispensing plants within city limits; total capacity of LPG storage amounts to 225,000 gal, contained in 18,000-gal water tanks; safety record showed no property damage or personal injury; cardinal rules for successful LPG operation and list of 19 items comparing LPG with other standard fuels; advantages.

Heavy Fuels for Railroad Diesels, W. F. COLLINS, K. D. RELYEA, B. W. GEDDES, N. H. RICKLES. Presented Jan., 1957, 32 p. New York Central System in cooperation with Esso Research & Engineering Co. conducted stationary locomotive tests which indicated that residual distillate type fuel of 300 SSU viscosity at 100 F gives satisfactory operation in EMD F-7 freight locomotive equipped with 567 B-16 engine when used in conjunction with dual fuel system; test program; fuel inspection data; charts.

Are Light Residual Oils Economy Locomotive Diesel Fuels? P. V. GARIN, J. L. BROUGHTEN. Presented Jan., 1957, 17 p. Economic study of performance of dual fuel locomotive fleet compared with similar number of engines operating on distillate fuel; dual fuel system utilizing light residual fuel of about 300–400 SSU at 100 F viscosity gave most satisfactory results with minimum expenditure for special equipment; all of data are based on this type; equations permit calculation of savings over any period of time with any number of locomotive units.

Trends in Residual Fuels, R. W. Van SANT, Jr., A. S. ORR. Presented Jan., 1957, 20 p. Changes during last 15 yr and effect on present day residual fuel availability and properties; data on supply and end use of residual fuels; effect of crude oil properties, and refinery processes on production and properties; tables give ASTM residual fuel oil specifications, properties of No. 4, 5, and 6 fuel oils.

Laboratory Full-Scale Engine Testing of Railway Type Fuels, J. D. CARMICHAEL, J. V. KALB, P. KALIL. Presented Jan., 1957, 11 p. Tests at Texas Co. of average type of residual distillate blended fuel in full-scale railway diesel locomotive engine; two engines tested were 6-cyl 2-cycle engine and 12-cyl 4- cycle engine developing 1700 hp; it is concluded that No. 5 fuel oil blends can be used with advantages and penalties enumerated.

Bi-Fuel Approach to Burning Residual Fuels in Diesel Engines, W. C. ARNOLD, R. H. BEADLE, R. L. LOGELIN, H. D. YOUNG. Presented Jan., 1957, 28 p. Work by Sinclair Research Laboratories and Fairbanks, Morse & Co. on Bi-Fuel Combustion Process embodying 2-fuel combustion system whereby small percentage of auxiliary fuel is introduced into engine cylinder either during intake or early in compression stroke of cycle, prior to nor-

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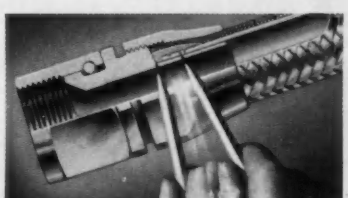

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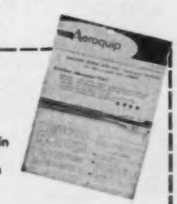

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Briefs of SAE PAPERS
(continued)

mal injection of primary diesel fuel; types of engines and fuels used; effect on combustion; performance, and laboratory tests; diagrams.

Microscopy in Examination of Diesel Fuels, F. G. ROWE, H. F. NICOLAYSEN. Presented Jan., 1957, 7 p. Possibilities for facilitating study of diesel fuel quality by use of phase and polarized light microscopy to supplement electron micrographs; applicability of techniques where more data are desirable for correlating morphology and concentration of solid particles with storage stability and engine performance; photomicrographs.

GROUND VEHICLES

Propulsion Dynamics of Motor Vehicles, E. F. FARRELL. Presented Jan., 1957, 11 p. Wide-open-throttle performance of motor vehicle can be calculated with reasonable accuracy, provided certain basic data are available; free engine acceleration curve is also required, purpose of which is to compensate for lags in carburetion, ignition, etc; method for evaluating these lags and calculating procedure given; sample calculations on small automobile with automatic transmission and torque converter.

Planning New Automobile, J. E. JUDGE. Presented Jan., 1957, 24 p. Market determines need for and type of product; 2-year market study and its growth aspect caused Edsel Div., Ford Motor Co. to develop new Edsel car line in medium-price field; Ford's Merchandising and Product Planning for coordinating development of new product.

Efficient Operation of Gasoline-Powered Motor Vehicles, A. A. KEEFER. Presented Jan., 1957, 4 p. Study was made on 1000 vehicles to determine cause of mileage decrease in fleet operation of 4000 vehicles at Bell System; study covered gasoline mileage and combustion analysis, evaluation of mechanical adjustments, etc; as result of tests, driver training program and training program and training course was formulated establishing nine driving rules; gasoline mileage increased to 11.4 mpg at end of 1955.

Proper Selection of Refrigeration and Heating Equipment for Protective Transportation Bodies, H. G. STRONG. Presented Jan., 1957, 12 p. Material is offered regarding owning, operating, and lost revenue cost comparison procedure that operator can follow as guide; method assists in determining what combination of insulated vehicle, method of refrigeration and refrigera-


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Briefs of SAE PAPERS

(continued)

tion equipment would best serve in meeting particular needs.

Quality Car Structure—Evaluation and Development of Stiffness Factors. G. J. ENGELHARD. Presented Jan., 1957, 10 p. Evaluation and development of stiffness, by means of laboratory and road testing at Chevrolet Motor Div. of GM, has proved vital to reduction of shake and vibration and to development of quality car structure; types of tests outlined.

Refrigerated Van Bodies for Frozen Food Transport, J. D. JOHNSON. Presented Jan., 1957, 6 p. Features of over-the-road evaluation tests to establish temperature requirements for frozen food transportation in refrigerated van bodies; lack of uniformity in test results suggests need for further research; program to develop standard method and apparatus for determining heat gain ratings and air infiltration of refrigerated trailers has been referred to American trucking associations.

General Motors Fuel Injection System. Presented Jan., 1957, 24 p. Paper consists of three parts: Basic Development, **J. DOLZA**; Production Development, **E. A. KEHOE, D. STOLTMAN**; Application Development, **Z. ARKUS-DUNTOV.**

Electrojector—Bendix Electronic Fuel Injection System, A. H. WINKLER, R. W. SUTTON. Presented Jan., 1957, 9 p. System, devised by Bendix Aviation Corp, as novel approach to fuel injection problem for passenger-car installation, utilizes electronic control to modulate operation of solenoid injection valves; it has timed intake port injection and low pressure, 20-psi common rail fuel system employing controls that are responsive to intake manifold pressure, engine speed, air pressure, and temperature.

Field Requirements of Oil Seals, A. O. BEER. Presented Jan., 1957, 7 p. Summary of field experience with LeTourneau-Westinghouse Model C Tournapull oil seal, applied on clutch housing of 7C transmission in 20-ton machine with tournamatic drive, located in transmission coverplate and retaining EP gear oil in case; development of high temperature Hycar compound for dry running characteristics was found to be satisfactory in laboratory and field service for primary and auxiliary lip of seal.

Laboratory and Field Development of Oil Seals as Applied to Crawler Tractors, J. L. HILDENBRAND. Presented Jan., 1957, 11 p. Research and development program for improvement of bearing seals of track rollers of crawler tractors; study carried out over 5 years at International Harvester Co.; factors in design of test fixture to evaluate seal characteristics; three stages of laboratory tests and field tests.

Resilient Face Seals for Tractor Final Drives, F. S. ENGELKING, M. C. KEYS. Presented Jan., 1957, 9 p. How Caterpillar Tractor Co. developed improved tractor final drive seals, located on each side of sprocket to keep oil in and mud out of gears, bearings, etc; function of each part of sealing system is analyzed and performance of entire seal evaluated as unit; all of data given such as oil leakage, temperatures, load, waviness, torque, and misalignment are data obtained in laboratory test machine.

Oil Seal Applications in Farm Tractors, R. CANDEE. Presented Jan., 1957, 7 p. John Deere Waterloo Trac-

Briefs of SAE PAPERS
(continued)

tor Works' Procedure in approaching oil seal application by establishing general design proportions and operating conditions and securing recommendations of manufacture of oil seals; seal applications on right hand crankshaft bearing discussed; experience with three basic types on front wheels, namely: packing, lip, and face type seals; power steering hydraulic pump and operating conditions; selection of seal and assembly practices.

Size, Structure, and Export Performance of Western European Automobile Industry, L. POMEROY. Presented Jan., 1957, 38 p. Size and location of Western Europe automobile industry and influence of numbers on production costs; position of motor manufacturing components of four principal nations (Great Britain, Germany, France, and Italy); statistics on output, exports, employees, etc; tables.

Cadillac Frame—New Design Concept for Lower Cars, pt 1: S. L. MILLIKEN, pt 2: J. R. PARKER. Presented Jan., 1957, 25 p. Pt 1: Development of "tubular center-X" frame design and styling features of Eldorado Brougham 1957 car at Cadillac Motor Car Div. of GM. Pt 2: A. O. Smith Corp.'s development of basic idea and experimental phases and testing leading up to production designs.

Chrysler Torque-Flite Transmission, S. D. JEFFE, B. W. CARTWRIGHT. Presented Jan., 1957, 11 p. Transmission, presently used in Plymouth, Dodge, DeSoto, Chrysler, and Imperial models, consists of 3-element torque converter coupled to automatic 3-speed planetary gear box providing neutral and three forward driving ranges and reverse; push button control system; three types of torque converters; power flow; hydraulic controls; chart shows control system in drive (breakaway) half throttle; design details.

Chevrolet Turboglide Transmission, F. J. WINCHELL, W. D. ROUTE, O. K. KELLEY. Presented Jan., 1957, 12 p. Turboglide is nonshifting concurrent gear multiple turbine torque converter transmission with dual stator blade control having no low gear and incorporating 5-element torque converter, pump, three turbines, and dual stator; operating principles; coaxial arrangement illustrated function by function; control system; development aspects of grade retarder, converter thrust, and overrunning clutch.

Turbocharging Series 71 Engine, J. J. MAY, V. C. REDDY. Presented Jan., 1957, 20 p. How Detroit Diesel Engine Div. of GM investigated turbocharging process of 2-cycle engine, its effect on engine life and operating conditions; studies made considered compressor calibration, minimum air requirements of engine, use of variable nozzle between engine and turbocharger, method of rating engine, fuel governor, etc.; it is believed that engine will prove economical and reliable for applications requiring maximum power with minimum of engine size and weight.

Trends in Valve Gear Design, C. VOORHIES, N. FELBINGER, G. R. BOUWKAMP. Presented Jan., 1957, 12 p. Development of diesel engine toward higher speeds and power output has increased requirements of valve gear; effect of each of components on rest of valve gear design must be taken into account; problems involved in obtaining satisfactory valve gear operation; consideration of methods and equipment such as Stroboscope, Stroborometer, Lashograph, oscilloscope, and hydraulic lash adjusters; advantages of latter.

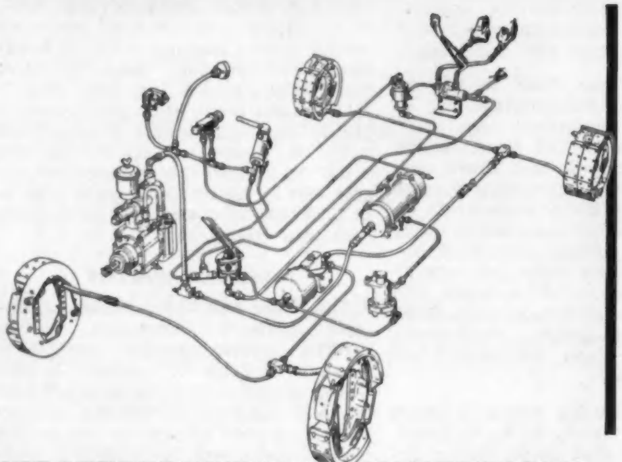
Continental 750-Hp Aircooled Diesel Engine, H. H. HAAS, E. R. KLINGE. Presented Jan., 1957, 28 p. Design developed to reduce fuel consumption of gasoline engine powered combat vehicles by 40%; new light weight powerplant develops rated output at 2400 rpm; basic features are: 5.75 in. bore × 5.75 in. stroke, 1790 cu in. displacement. Compression ignition, 4-stroke cycle, direct injection system, 90° Vee, 12-cyl. aircooling, and exhaust turbocharged arrangement; design details; performance analysis.

Design and Development of New Hercules Interchangeable Diesel Engine, J. F. MALE. Presented Jan., 1957, 25 p. Effort to devise basic engine of flexible design meeting needs of many diverse end-product manufacturers; features of gasoline and diesel models in 3, 4, and 6-cyl sizes, with bores of 3½, 3¾ and 4 in.; stroke of all engines is 4½ in.; range is 25 hp at 1200 rpm to 130 hp at 3000 rpm for gasoline engine and 25 hp at 1200 rpm to 100 hp at 2000 rpm for diesels; use in tractors, industrial trucks, etc.

NUCLEAR ENERGY

The Atom and SAE—Report of Nuclear Advisory Committee, C. R. LEWIS. Presented Jan., 1957, 5 p. Resume of fields of interest to SAE which appear most likely to be affected by developments in nuclear energy; uses of nuclear energy for production of heat and power, for vehicle propulsion, and for chemical processing; new materials of interest in this field; com-

Wagner AIR-OVER-HYDRAULIC BRAKES increase payload capacity and offer these six important operating advantages!



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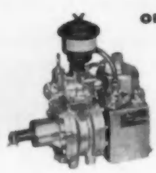

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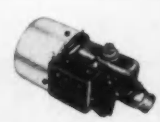

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ponents of nuclear machinery; use of radioactive materials produced in nuclear energy machinery as research and manufacturing tools.

Effects of Radiation on Materials, M. FERENCE, Jr. Presented Jan., 1957, 13 p. Nature of changes occurring in physical and mechanical properties of materials subjected to various types of radiation; basic mechanism of radiation damage; effects on metals, such as steel, aluminum, etc., and nonmetals; radiation as source of energy for chemical reactions; vulcanization of rubber; results of some recent experiments; tables.

Safety Aspects of Use of Nuclear Energy, C. R. RUSSELL. Presented Jan., 1957, 9 p. Engineering aspects involved in reactor safeguards problem; hazards associated with reactor operation as result of accumulation of fission product within fuel; effects of radiation; magnitude of hazard; insurance problem; mechanisms of release of fission products; hazards control; operating experience.

PRODUCTION

Forged Steel Crankshafts, H. F. WOOD. Presented Jan., 1957, 16 p. Quality control begins in open hearth or electric furnace where steel for forging quality bars and billets is made; rolling and forging process; tabulation of steels most commonly used; metallurgical quality control; heat treatment; centering and dynamic balance control, and final inspection; mechanical properties; effect of modulus of elasticity and endurance limit on crankshaft design; evaluation of material.

Shell Molded Cast Crankshafts, H. N. BOGART. Presented Jan., 1957, 13 p. Development of process at Ford Motor Co., from original cast crankshaft in 1933, and including 2-step evolution from forged to shell molded crankshaft; typical chemical analysis; physical properties obtained with nodular iron.

Some Metallurgical Aspects of Pontiac V-8 Engine Pearlitic Malleable Iron Crankshaft, K. B. VALENTINE. Presented Jan., 1957, 12 p. Method used to produce crankshaft castings for 316-cu in. displacement, 8.9 to 1 compression ratio engine consists of adjusting annealing cycle to control degree of graphitization; coupled with aircooling and tempering, process results in structure of temper carbon in matrix of pearlite; engineering and metallurgical properties; machining experiences; other properties of pearlitic malleable iron.

Myths and Fallacies of Automation, J. R. BRIGHT. Presented Jan., 1957, 24 p. Fallacies and phobias of automation examined to interpret and anticipate some of ultimate effects of mechanization in automotive field; experiences of 13 highly automatic production systems in variety of industries studied and trends and results checked against experiences of 30 firms; tables.

Yardstick for Automation, G. H. AMBER, P. S. AMBER. Presented Jan., 1957, 9 p. Attempt is made to define, classify, and evaluate automation; 10 orders of automation are established and automaticity scale for measuring automation is developed based on two factors which are identified as energy and information; example of yardstick; how to solve computer control equations.

These digests are provided by Engineering Index, which abstracts and classifies material from SAE and 1200 other technical magazines, society transactions, government bulletins, research reports, and the like, throughout the world.

New Members Qualified

These applicants qualified for admission to the Society between March 10, 1957 and April 10, 1957. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

Robert Orville Lockwood (M).

Atlanta Section

Charles L. Adams, Jr. (M), Robert P. Sudderth (J).

Baltimore Section

Robert C. Butscher (J), Joseph J. Kaufman (J), Charles F. Waters (M).

British Columbia Section

George Curley (A), James Monroe Lundblom (M).

Canadian Section

Leonard F. De Santis (A), R. G. Murley (A).

Central Illinois Section

William H. Belke (M), William E. Frank (M), Joseph V. Miller (J), Clyde L. Pritchard (M), Jack Thomas Sydenstricker (J), Harry H. Washbond (M).

Chicago Section

William K. Biery (A), Richard G. Cox, Jr. (A), John B. Durant (J), Gordon D. McKittrick (M), Howard J. Slothower, Jr. (J), Frederick Snoy (M).

Cincinnati Section

Kenneth K. Finzel (J), Ernest J. Haas (J), William G. Williams (M).

Cleveland Section

Otto A. Ahlegian (M), Robert J. Broadwell (M), Eugene D. Cowlin (M), James G. Fletcher, Jr. (J), Robert Julian Laws (M), Edmund Lis (J), Einor E. Lund (M), Samuel James Oakes (J), William C. Woodward (A).

Detroit Section

Robert Bollens (M), Robert W. Broberg (M), William E. Butts (M), Joseph L. Cannella (J), Raymond Eugene Clark (J), Clifford G. Currie (M), H. Bernard Ernst (J), Charles H. Fletcher, Jr. (A), Robert E. Harvie (M), Benjamin T. Howes (M), Gordon H. Johnson (A), Andrew G. Leber (M), David Levitin (J), Walter S. McPhail (J), Ernest A. Parkanzky (J), Alex M. Pentland (M), James R. Ritzema (J), Wesley J. Schultz (M), Joseph James Simone (M), Robert W. Stapleton (M), James B. Stewart, Jr. (A), Elmer C. Stringham (J), Edward F. Thomas (M), Ernest A. Tsakiris (M).

CONTINUED ON PAGE 148

NEW

Tachometer Take-Off

...for VEEDER-ROOT Rev-Counters

With this new attachment, Veeder-Root Rev-Counters can be installed on any engine having a tachometer take-off in a position which is readily accessible for easy reading. Take-off can be furnished to suit average engine-speed.

So now you can make it easier than ever for your customers to see that your product is performing up to its guarantee . . . to see when routine maintenance is coming due, and whether servicing is needed.

You can count on Veeder-Root to figure out how to engineer these adaptable Rev-Counters into *your* products . . . not only engines, but generators, compressors, heaters, refrigerators, and what have you? Write:

Everyone... Can Count on

VEEDER-ROOT
INCORPORATED

HARTFORD 2
CONNECTICUT

New York 19, N. Y.
Greenville, S. C. • Chicago 6, Ill.
Montreal 2, Canada
Offices and Agents in Principal Cities

BENDIX-WESTINGHOUSE AIR BRAKES

Best buy for your trucks because they're preferred by America's leading fleet operators!

"In our 24 years in business

We've bought 1,135 trucks

AND WHEN IT COMES TO AIR BRAKES, WE PREFER

Bendix-Westinghouse!"

THE WORLD'S MOST TRIED AND TRUSTED AIR BRAKES

MR. E. WARD KING, President, The Mason and Dixon Lines, Inc.

From his company's general headquarters in Kingsport, Tennessee, Mr. King directs the activities of a dynamic trucking firm providing fast, efficient service to shippers and receivers along the Eastern Seaboard and Midsouthern United States. Mason and Dixon rigs, in 1955, rolled up a total of over 26 million miles while operating on routes totaling 6,000 miles. The company maintains 26 modern terminals and employs 1,500 people.

"IN OUR 24 YEARS OF BUSINESS

We've bought 1,000 trucks

AND WHEN IT COMES TO AIR BRAKES, WE PREFER

Bendix-Westinghouse!"

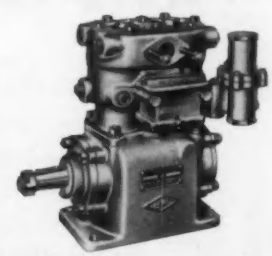
THE WORLD'S MOST TRIED AND TRUSTED AIR BRAKES

MR. JOHN BISGROVE, President Red Star Lines of Auburn, N. Y., Inc.

From his company's general headquarters in Auburn, New York, Mr. Bisgrove directs the activities of the largest motor carrier domiciled in the state of New York. Red Star Express Lines serves the states of New York and New Jersey and maintains eight [illegible] located terminals. The company employs over 750 people and in 1955 rolled up over [illegible] total miles.

It is a rarity indeed when a product in any field demonstrates customer preference so strong that it continually *outsells all other competition combined* year after year. Yet, for the past twenty-seven years, this has been the remarkable accomplishment of Bendix-Westinghouse Air Brakes in the truck and bus fields! In fact, recognition of the greater safety, economy and dependability of Bendix-Westinghouse Air Brakes by truck buyers has resulted in their factory installation on more and more truck models of all sizes.

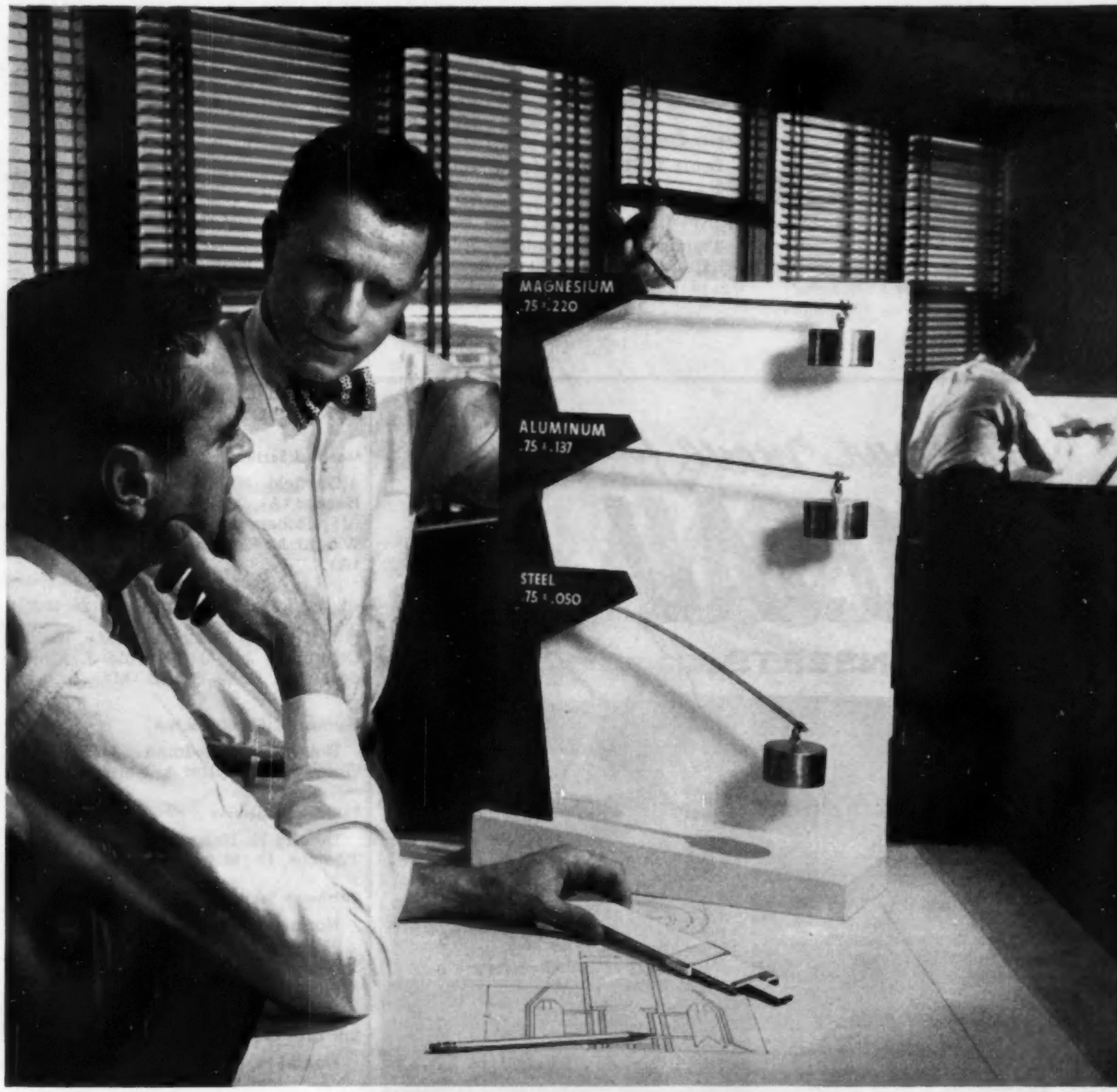
Chances are good that your trucks, too, offer the many advantages of these powerful brakes. If not, we suggest you take advantage of the proven superiority of Bendix-Westinghouse Air Brakes by offering them as factory-installed equipment. It's one sure and easy way to add more sales-appeal to your vehicles!



Over 2,000,000 compressors, produced over a twenty-seven-year span, stand behind the TU-FLO 400. Many advanced features guarantee performance no other compressor can equal.

Bendix-Westinghouse AIR BRAKES

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE COMPANY • General offices and factory—Elyria, Ohio. • Branches—Berkeley, Calif., and Oklahoma City, Okla.



Rigidity! At equal weight, magnesium is 18 times stiffer than steel

Magnesium's unique combination of strength and light weight gives it some outstanding abilities as a structural metal. Take rigidity, for example. A magnesium bar has 22% the stiffness of a steel bar of the same dimensions.

But stiffness increases as the cube of section thickness. So, if thickness of the magnesium is increased to twice that of the steel, the magnesium bar will be over 70% more rigid—yet weigh only half as much. And if thickness is further increased until the bars are of equal weight, the magnesium bar will be 1878%—or over 18 times—more rigid!

Similarly, a magnesium bar of equal rigidity to an aluminum bar will weigh only 75% as much as the aluminum bar. At equal weight, the magnesium bar will be over twice as stiff.

From these facts it's easy to see that magnesium can do a structural job equal to or better than steel and aluminum—and with appreciable savings in weight—whenever it's practical to increase section thickness. For more information contact the nearest Dow sales office or write to us. THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Department, MA 1402D.

YOU CAN DEPEND ON DOW

New Members Qualified

Continued from page 142

Hawaii Section

Claude Francis Bartlett (A), Manuel Sylvester (A).

Indiana Section

James Robert Eddy (J).

Kansas City Section

Louis L. Tigner (A), M. H. Wessel (M).

Metropolitan Section

Thomas V. Fitzgerald (A), Samuel W. Handley (M), William B. Silvestri, Jr. (J), William B. Smyth (J).

Mid-Continent Section

Eugene T. Speller (J).

Mid-Michigan Section

Paul R. Clark (A), Edward N. Harris (M), William D. Howell (M), Hugo Lundberg, Jr. (M), Lindbergh C. Vogt (M).

Milwaukee Section

Frank C. Skelton, Jr. (M), James G. Williams (A).

Mohawk-Hudson Section

Sanford C. Cockrell (M), John H. DeWitt (M).

Montreal Section

Garfield Kehl Bowser (J), Albert Heeds (A), James Arthur Hutchins (J), Robert F. MacKie (A), William Wright McKenzie (M), Ronald Whyte (A).

New England Section

J. Kenneth Baxter, Jr. (M), William Commans, Jr. (J), Harold J. Elmendorf (M), R. W. Smith (M).

Northern California Section

Robert L. Friedman (J), Pratt L. Greer (J), Clayton A. Norelius (J).

Philadelphia Section

Donald H. Hanson (M), William W. Thomas, II (M).

Pittsburgh Section

Norman M. Zanardelli (J).

St. Louis Section

George A. Feyerabend (M).

Salt Lake Group

Daniel M. Schwartz (M).

San Diego Section

Alan Weir Abels (M), J. J. Alkazin (M), G. Robert Blayzor (J), Robert J. Chillo (M), John S. Hahn (M), Ernest F. Kotnik (M), Jimmy Pisciotta (M), Donald M. Post (M), William M. Thomas (M).

Southern California Section

Grant C. Adams (M), William T. Barker (M), George W. Brooks (M), Lawrence L. Elder (M), Thomas C. Fenwick (M), Ted Grondona (A), Raymond P. Martin, Jr. (J), Charles E. Painter (M), Wilton E. Parker (M), Edgar Schmued (M), Philip H. Williams (J).

Southern New England Section

George H. Raley (M).

Texas Section

Francis R. Dunn (J), Donald Arthur

New Members Qualified

Continued

Siedhof (J), Jack B. Sparkes (A), Daniel W. Wildfong (M).

Texas Gulf Coast Section

Henry G. Coffman (A).

Virginia Section

Charles E. Gray, Jr. (J).

Washington Section

James E. Doran (A), Douglas A. L. Robson (M), Alfred Everett Savage (M).

Outside Section Territory

Charles J. Brady (M), Robert E. Greenman (M), Joseph F. Wagner (M), John Russell Wright (M).

Applications Received

The applications for membership received between March 10, 1957, and April 10, 1957, are listed below.

Atlanta Section

Nicholas J. Pratt, Howard B. Simkins.

Alberta Group

William George Anderson, William N. Csokonay.

Baltimore Section

W. F. Whitesides, Gilbert Wilkes, III.

British Columbia Section

Ronald B. Thicke.

Buffalo Section

Claude V. Hawk.

Canadian Section

Keith Blackburn, John Stuart Bright, J. A. Carruthers, E. W. Clayton, A. J. Renwick.

Central Illinois Section

Walter F. Anderson, Eugene L. Caldwell, Robert E. Hoffert, George H. Nelson, Richard R. Smith, Edward W. Snell.

Chicago Section

Stanley J. Adams, Charles L. Alpaugh, Ronald Keith Dickason, James Bernard Kearney, Arnold Dean Kincaid, Marvin J. Klima, Frank J. Kozumplik, Jr., James H. McInerney, Horace W. Neill, Kenneth J. Nicholson, Gustaf H. Olson, Robert Edmund Reichard, Robert B. Woltman.

Cincinnati Section

James F. Brown, Howard G. Mallinger, Clyde K. Turley.

Cleveland Section

James A. Creedon, T. R. Fredriks,

Applications Received

Continued

Warren B. Grote, John G. Harmath, Robert E. Hughes, Robert K. Nelson, Robert L. Williams.

Dayton Section

Robert G. Hollifield, Sr., Charles Edward Lloyd.

Detroit Section

Sidney Astourian, Howard A. Aula, Charles D. Branigin, Raymond Joseph Cedar, William Cholewka, David H. Davies, Robert L. Dega, Anthony Francis Dubeck, Richard K. Eshelman, Earl K. Fake, Gerald F. Fox, Daniel T. Franklin, Michael Angelo Fusco, Chester Gieldowski, William John Hallauer, John C. Hampson, Harvey A. Hedlund, David L. Hill, Warren Deem Hirschfield, Harvey G. Humphries, Theodore S. Jentsch, Jr., Paul R. Kelps, Leslie S. Kobylinski, George W. Landon, Ronald S. N. Lee, George H. Lowande, Jack C. McLauchlan, John Riordan Neff, Albert C. Nichols, Ross E. Nielsen, Edward R. O'Neill, Jr., Vaughn Allen Patterson, George Petitpren, Jr., Daniel H. Pierce, Milton C. Portmann, Jr., J. Doyle Ryan, Robert V. Sharkey, Eugene E. Sowers, Karl-Gustav Stark, Richard L. Swart, Jerome A. Trapp, Fred H. Watson, John C. Witwer, Henry M. Woodhouse, Ming-Chih Yew.

Indiana Section

Don J. Bowling, George W. Bruner, Merle Dalton Coy, Heinrich Davatz, A. W. Earleywine, Jr., Raymond E. Gill, Gerald L. Gremaux, James W. Kleinschmidt, David E. Lucid, Glenn E. Mather, John Carlton Nordman, Leland L. Reich, Milton B. Snyder, Richard Loren Staadt.

Metropolitan Section

George G. Brown, Joseph H. Budd, Joseph S. Cascio, Francois Crouzet, Malcolm D. Earle, M. F. Fansler, Michael Henry Farmer, Karl G. Granlund, William T. Haupt, Arnold Jacob, Martin L. Kapin, Frank J. Kowalkowski, John D. Loftis, Russell M. Osborne, Edward W. Purcell, Carl W. Schonfeld, William Weinstein, John S. Zsido.

Mid-Continent Section

Herman Charles Inlow.

Mid-Michigan Section

Jess C. Barrow, Harold J. Beuhler, Otto Andrew Kern, Oscar E. Sundstedt.

Milwaukee Section

Roy R. Buck, Donald E. Chaulk, Louis C. Mente, Philip A. Scheuble, Jr.

Mohawk-Hudson Section

Thomas J. Bradley, Anglo Di Sorbo, Robert Don, Edward J. Duncan, J. L. Flacke, Walter F. Venneman, Warren J. Waltson.

Montreal Section

Leopold K. Arnold, Reginald William Beech, R. Boyd Ferris, Raymond R. Gregory, Allan B. Newland, Gudmunour P. Peterson.

New England Section

Richard L. Bates, Chester A. VanderPyl

Northern California Section

William H. Albee, Jr., Robert D. Cowger, Sylvan F. Ellis, Frank B. Hurtubise, R. D. Larimer, Edward C. McLaughlin, Franklin A. Packard, John Luther Scruggs, George Street, Charles E. Wallick

Northwest Section

Bruce A. Douglas, Allen C. Mark

Oregon Section

Robert H. Feely, Walter Henry Nester

NEW

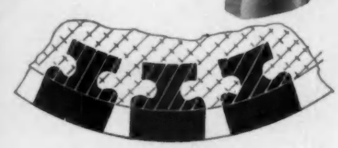
ESPECIALLY DESIGNED FOR TOP RING GROOVE PROTECTION IN PISTONS FOR GASOLINE ENGINES

AN ECONOMICAL METHOD WITH MINIMUM WEIGHT INCREASE

CAN BE APPLIED TO ANY TYPE ALUMINUM ALLOY PISTON

PERMA-GROOVE*

WITH SEGMENTAL STEEL TOP RING SECTION



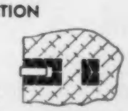
TOP RING SECTION

FRONT VIEW SECTION

Again, Zollner engineering leadership provides another great piston development to engine builders. The new Zollner "Perma-Groove" gives sensationally longer life to pistons and rings, prevents blow-by, minimizes oil consumption. The light weight segmental steel section incorporates high wear resistance in the top ring groove *plus* the advantage of cool operation. Designed especially for gasoline engine pistons, "Perma-Groove" is the quality, low-weight and low-cost companion to the popular "Bond-O-Loc" piston for Diesel engines. We suggest an immediate test of "Perma-Groove" advantages for your gasoline engine.

*T. M. Reg. Pat. App. For

OUTSTANDING ADVANTAGES OF ZOLLNER "PERMA-GROOVE" TOP RING SECTION



CROSS SECTION

1. Individual steel segments eliminate continuous band expansion problem.
2. Segments securely locked to prevent radial movement.
3. Dovetailed edges keep steel segments securely in plane with groove.
4. 75% steel bearing area for wear resistance.
5. 25% aluminum bearing area for heat conductivity and cool operation.
6. Light in weight.

ADVANCED ENGINEERING

PRECISION PRODUCTION

COOPERATION WITH ENGINE BUILDERS

ZOLLNER PISTONS

THE ORIGINAL EQUIPMENT PISTONS

ZOLLNER

ZOLLNER CORPORATION • Fort Wayne, Indiana

Applications Received

Continued

Philadelphia Section

J. Frank Canfield, George W. Koehn, Donald H. Milne, Wallace D. Stein, George A. Wallace

St. Louis Section

James W. Foster, Donald C. Hill, Leroy David Jansen, Thomas A. Sullivan

San Diego Section

Charles Douglas Beckner, Henry L. Behl

Southern California Section

Minoru Sam Araki, Bernard George Benaway, Charles E. Burns, J. F. Culp, Sanford J. Friedfeld, Karl Kenneth Kerns, John W. Peel, Jr., Dr. Benjamin L. Shaeffer, William Prichard Taylor

Southern New England Section

Charles W. Dixon, Raymond D. Hart, Thaddeus A. Lasek, Millard Girard Mayo, Howard W. Nelson, Anthony A. Pack, Gordon Sonner, James N. Sowers, Winthrop B. Vail, Max H. Voigt

Syracuse Section

H. Follett Hodgkins, Jr.

Texas Section

Vernon N. Ferguson, Stanley Edward Hildebrand

Texas Gulf Coast Section

John E. Valicek

Twin City Section

Arthur W. Boehm, Frederick A. Caswell, John William Gausman, Oliver W. Johnson, Joseph N. Moses

Virginia Section

Edwin S. Hawkins

Western Michigan Section

Thomas Shannon

Wichita Section

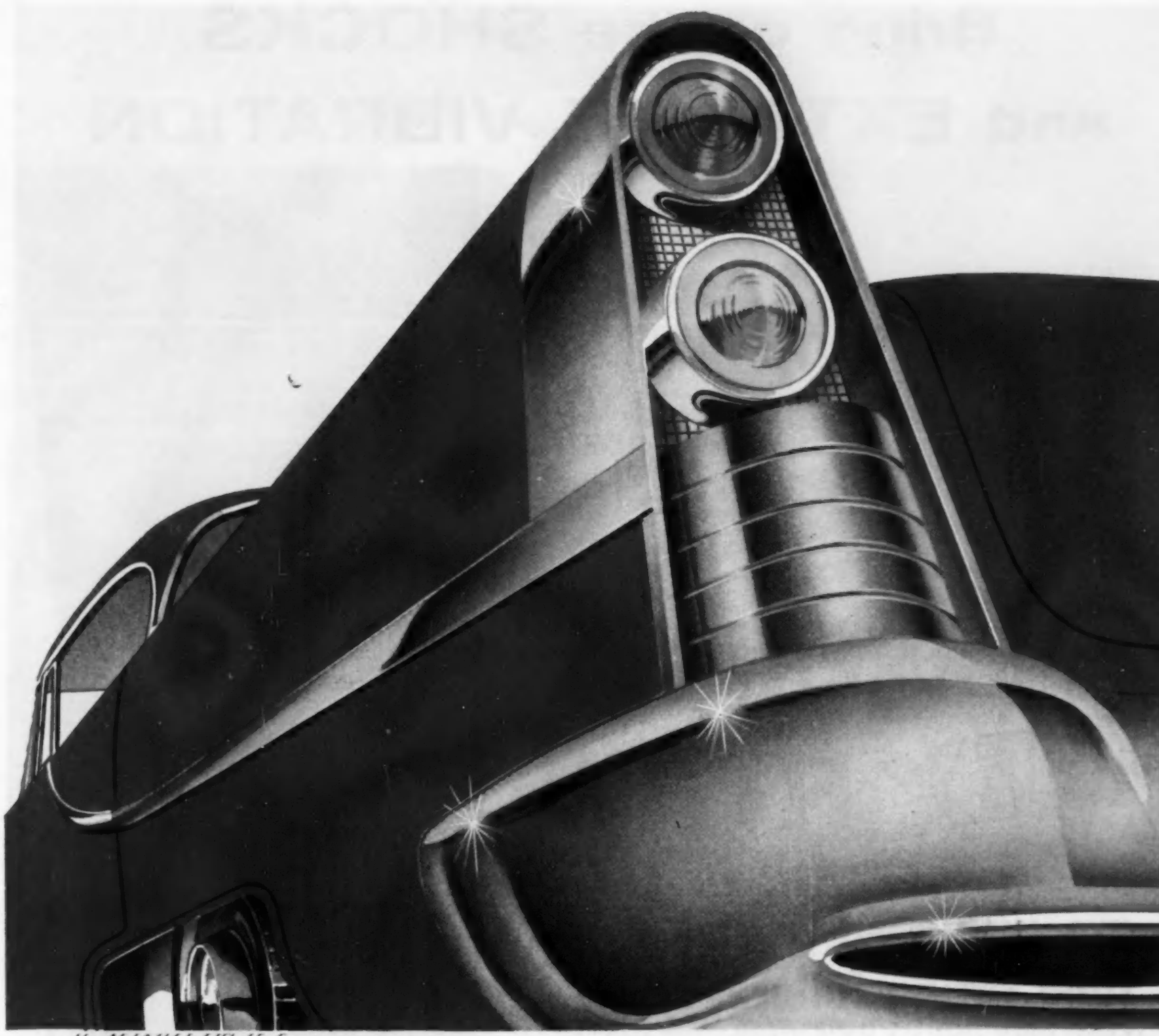
William J. Howell, Jr.

Outside of Section Territory

Harvey M. Bender, Gerald A. Doetsch, John P. Motrie, Charles C. Rape, Jr., Theodore C. Schallehn, Lawrence E. Schwietz, Charles A. Smiroldo, George A. Smith

Foreign

Armando Carvajal Alegre, Cuba; John Mather, England; Carl Gustaf Nystrom, Sweden; Charles A. Pickering, England; Thomas William Sommers, Australia; Christian P. Tschudi, Switzerland



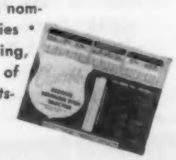
The beauty of Crucible stainless steel is its superior resistance to corrosion

Why do today's cars have as much as 55 lbs. of stainless steel per car? Because this metal is strong but lightweight, beautiful and durable, highly resistant to corrosion. It's the ideal metal for wheel coverings, window frames, top and body trim, grilles, taillight housings, bumper guards and instrument panels.

Tomorrow you'll be using even more pounds per car. For example, you may be able to use it for posts and pillars, chassis frames, floor and roof deck panels. And the beauty of designing with stainless is that your designs can easily be produced because of fabricators' extensive experience with this versatile metal.

Keep abreast of new developments in stainless steel by ordering *Crucible sheet and strip.* Crucible promptly supplies standard grades and finishes in practically any width and thickness. And if design and fabrication problems arise, Crucible engineers and research teams will cooperate with you in every way.

Free Stainless Steel Selector contains complete data: nominal composition of all grades • physical properties • resistance to corrosion, scaling • data on machining, welding, hardening. Write: *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*



CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

Bring on the SHOCKS and EXTREME VIBRATION

IMPERIAL FLEX® FITTINGS

are cushioned to end tube fitting failures!

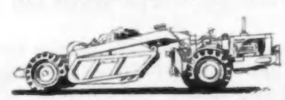
Imperial Flex fittings thrive on vibration, mechanical shock and minor tube movement. Eliminate a common cause of fitting failure . . . and the need for costly flexible hose lines in many cases. In fact, if properly connected, Flex fittings will never fail under extreme vibration.

Speed installation too — Simply slip nut and sleeve over tubing. Insert tubing into body and tighten nut. That's all! Make pressure-tight joints on all seamed and seamless tubing, including scored tubing or tubing with surface defects. Can be disconnected and reconnected repeatedly without danger of leakage! Even slight misalignment will not cause leakage.

Built to take punishment — Proved superiority on severe applications is a matter of record. Forged bodies on elbows and tees are tough, rugged. Sleeve withstands gasoline and oil . . . flexes perfectly in sub-zero to 250°F temperatures.

Why Flex fittings can't fail

Like resilient mountings for automobile engines, Flex sleeve permits tube to flex back and forth through angle shown. Tubing can't wear because metal-to-metal contact is snubbed. Flex fittings are available for ⅛ to ⅞" O.D. tubing.



Trucks, tractors, heavy power equipment, earthmovers all thrive on Flex fitting vibration-proof protection. Make a test application on your product NOW.

Write for Catalog No. 344.

IMPERIAL

THE IMPERIAL BRASS MFG. CO.
1225 W. Harrison St., Chicago 7, Ill.

In Canada: 334 Lauder Ave., Toronto, Ontario

Emblem of Quality

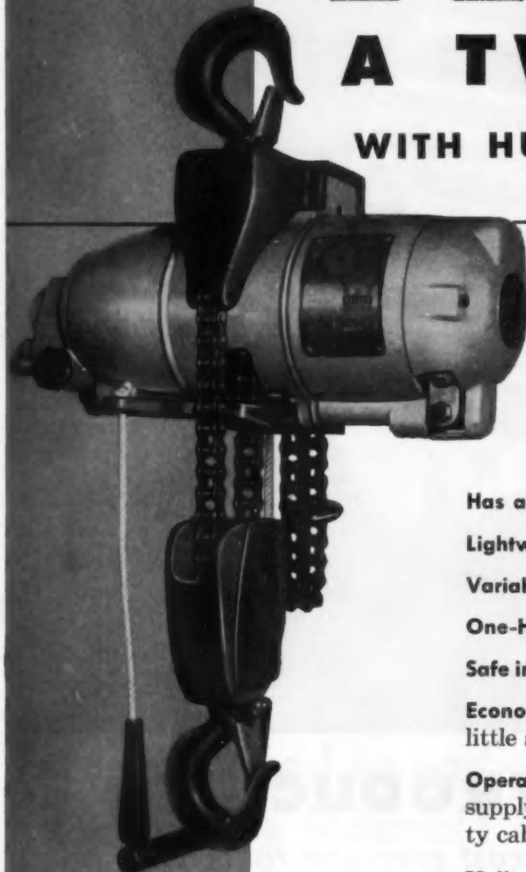
SEE YOUR IMPERIAL DISTRIBUTOR: for fittings and tools for copper, steel, stainless steel, aluminum and plastic tubing. He offers Industry's Most Complete Line.


TORRINGTON

NOW!

A TWO-TON LIFT

WITH HUSKY 100-POUND AIR HOIST



New Keller Tool air hoist weighs 100 pounds . . . raises a 4000-pound load at 10 feet per minute. Hoist is strong and powerful enough to handle the 2-ton load with complete safety.

New 2-ton hoist is powered by high-torque, axial-piston compressed air motor for positive starts and stops. A centrifugally governed, fully mechanical brake prevents slippage. Length of lift is 8 feet. Hook-to-hook dimension is only 23½ inches.

Has all the outstanding features of the Keller Tool air hoist line:

Lightweight—easy to move and hang.

Variable Speed—from creep to maximum.

One-Hand Control—of lifting, lowering, spotting.

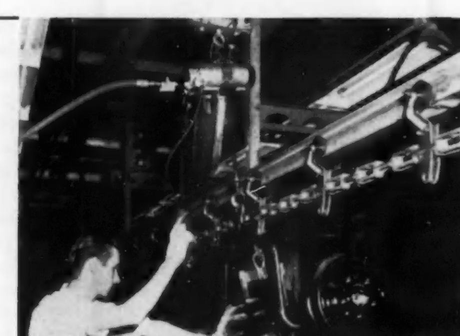
Safe in Heat or Dust—air motor doesn't spark . . . won't heat up.

Economical Operation—air consumption is low . . . requires little servicing or maintenance.

Operator Safety—powerful brake holds load regardless of air supply. An exclusive feature of the new two-ton hoist is a safety cable hole that provides extra safety for load and operator.

Keller Tool air hoists are available in lifting capacities of 150 . . . 300 . . . 500 . . . 1000 . . . 2000 . . . and *now* . . . 4000 pounds. Write for Bulletin 86.

Keller Tool air hoist, keeping pace with assembly line conveyor, lifts rear axle assemblies onto conveyor hooks.



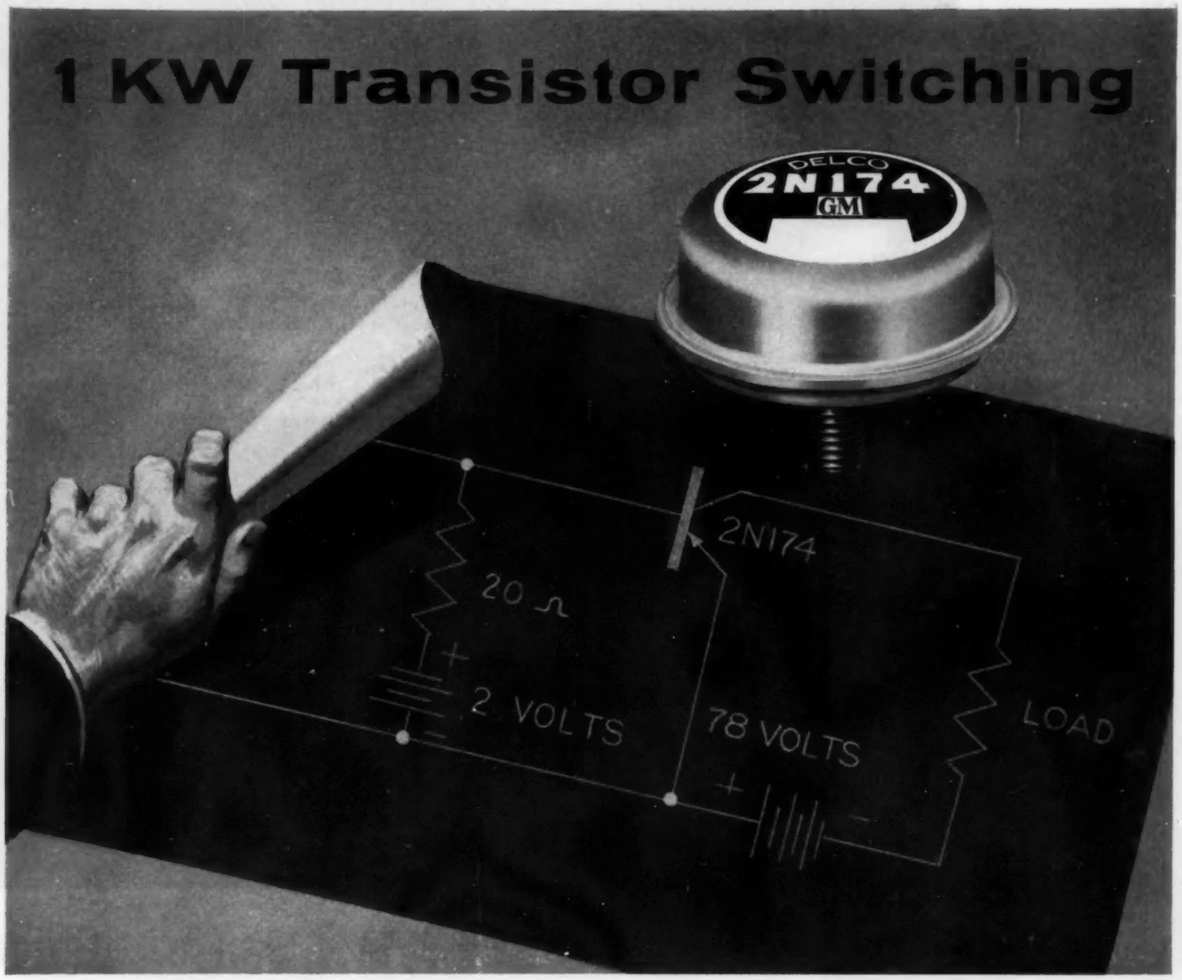
GARDNER-DENVER Since 1859

KELLER TOOLS

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois



Industry's Highest Power Transistor

Eliminate arcing at switch points. Stop switch deterioration while increasing the efficiency and reliability of all electronic control equipment!

A single Delco 2N174 transistor can switch 1 kw with one watt of control power.

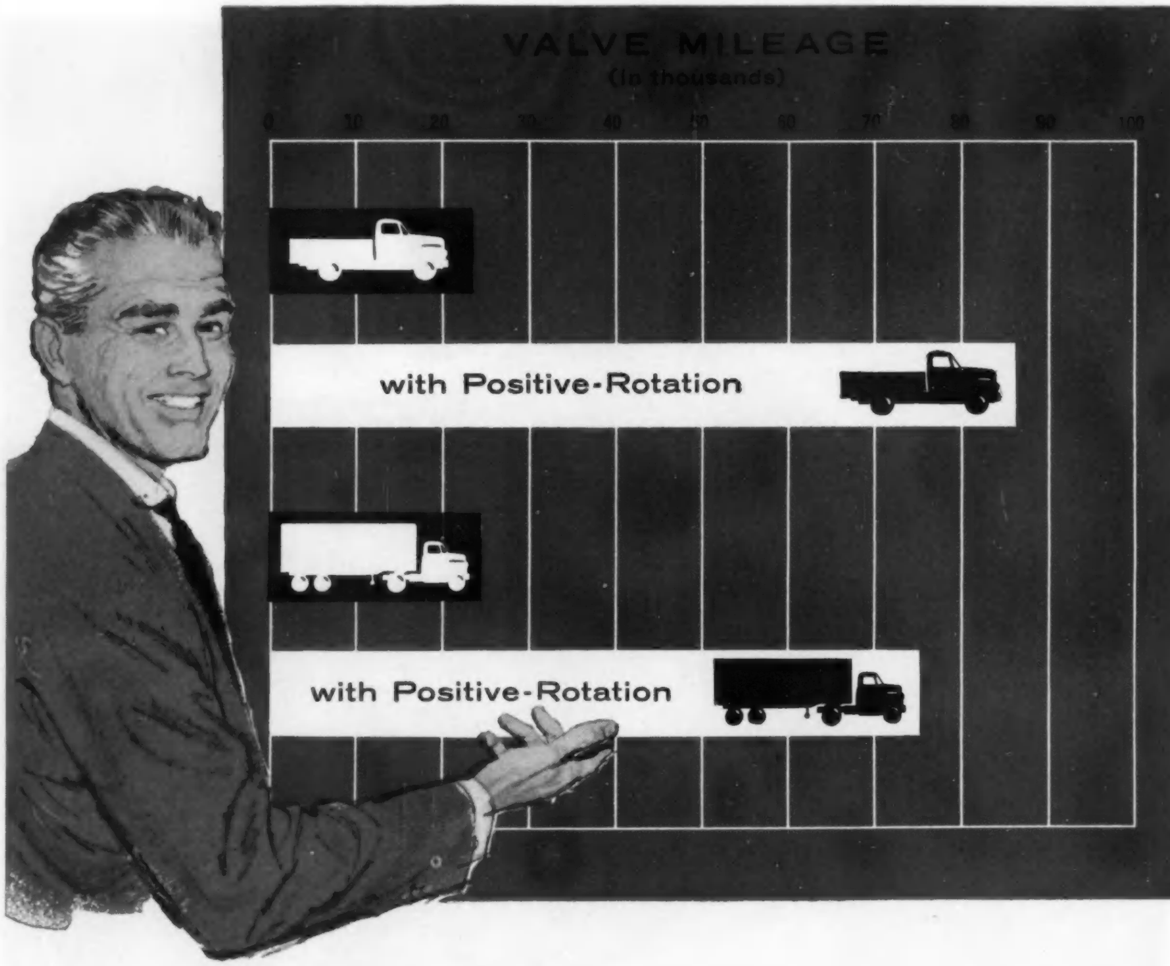
Because transistor switching eliminates arcing, switch life is longer and more reliable.

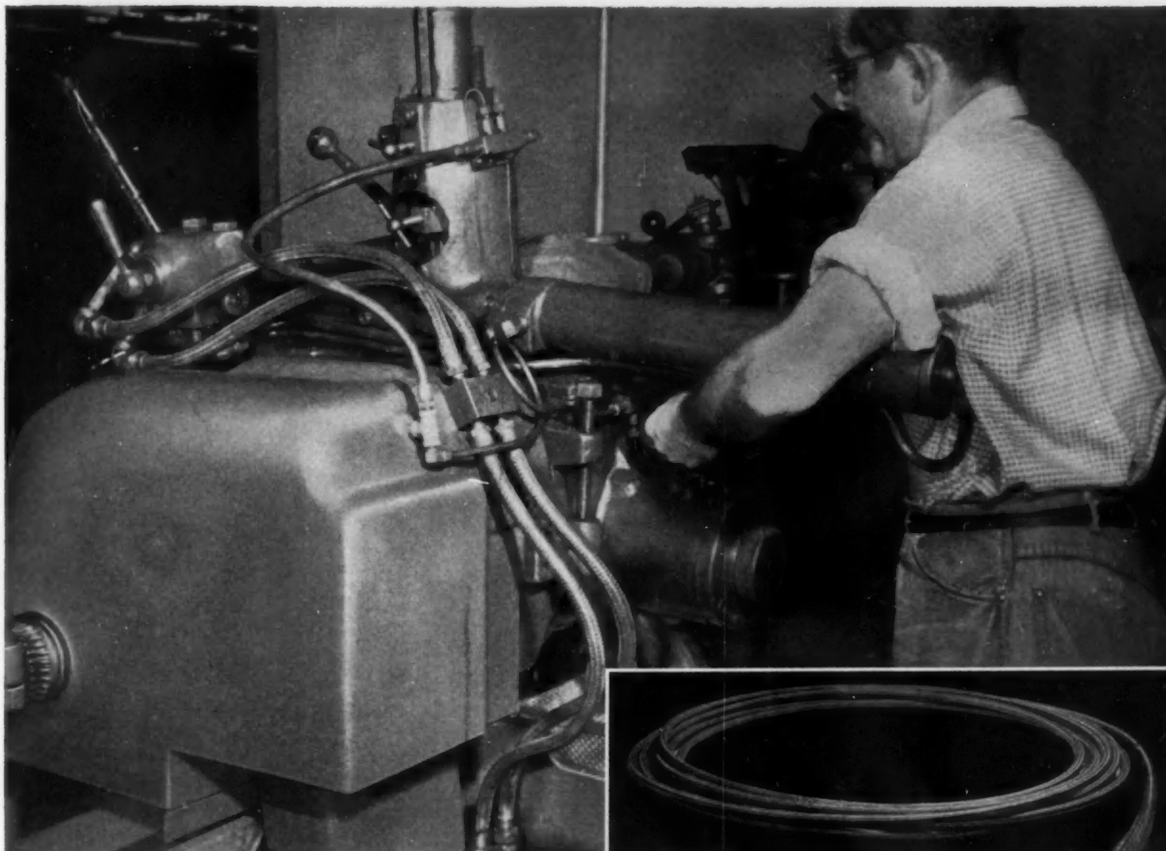
This switching performance is possible because of the excellent electrical characteristics of the 2N174; in particular, the high collector breakdown voltage, extremely high maximum collector current, and very low input impedance.

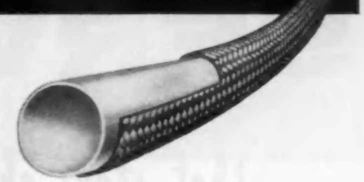
You may employ Delco 2N174 high-power transistors with confidence in their reliability and uniformity. These transistors, normalized to retain better performance characteristics regardless of age, are currently being produced by the thousands every day. Write for engineering data.

Power Switching Characteristics	
Switching Power	1000 watts
Current in "on" position	13 amperes
Input Control Power	1 watt
Power Gain	30 db
Dissipation in "on" position	8 watts
Switching time	60 microseconds

DELCO RADIO DIVISION OF GENERAL MOTORS
KOKOMO, INDIANA


VALVE MILEAGE
(in thousands)
0 10 20 30 40 50 60 70 80 90 100
with Positive-Rotation
with Positive-Rotation





Where to use R/M FLEXIBLE THIN-WALL Teflon* HOSE in automotive and aircraft applications

Wherever corrosive fluids, high mechanical stresses, or extreme ambient temperatures are involved in lines which must handle fuels, lubricating oil or hydraulic fluid, R/M Flexible Thin-Wall "Teflon" Hose provides easy solutions to difficult problems.

For example, take the precision centerless grinder above, which is used in the manufacture of critical aircraft components. Lines supplying its hydraulic infeed drive system must be flexible. They must handle cycling pressures in the range of 75 to 90 psi. R/M Flexible Thin-Wall "Teflon" Hose was found ideal for this troublesome application. It offers equal advantages in countless difficult aircraft and automotive applications, for it serves continuously in temperatures ranging from −100 to 400°F without failure, lasts many times longer than similar hose of other materials, and is unaffected by aging or the highly corrosive agents it may encounter.

R/M Flexible Thin-Wall "Teflon" Hose, with wire-braided or rubber cover, is available through leading coupling manufacturers. We have pioneered in the development of products of "Teflon" for use in the automotive and aircraft fields. Write us for complete specifications on R/M "Teflon" products and name of nearest supplier.

*A Du Pont trademark

Other R/M "Teflon" products for the automotive and aviation industries include rods, sheets, tubes and tape; centerless ground rods held to very close tolerances; stress-relieved molded rods and tubes; and Raylon, a mechanical grade of "Teflon" with many of the properties of virgin "Teflon." For details, call or write R/M.

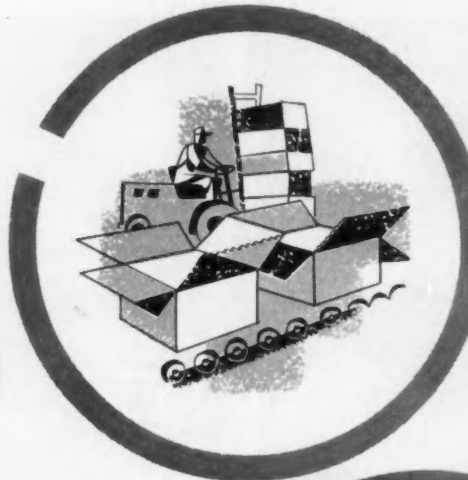
R/M

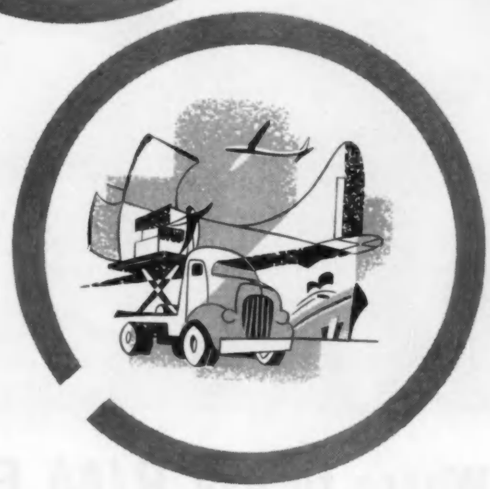
RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION, MANHEIM, PA.

FACTORIES: Manheim, Pa.; Bridgeport, Conn.; No. Charleston, S.C.; Passaic N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber • Sintered Metal Products • Rubber Covered Equipment
Brake Linings • Brake Blocks • Clutch Facings • Abrasive and Diamond Wheels • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls





RING SERVICE

that stays ahead of your production deadlines

Nothing succeeds like *timing* . . . especially in a mass production world where output can be measured by the minute! That's why McQuay-Norris service includes unusual precautions to assure delivery *when* and *as* specified!

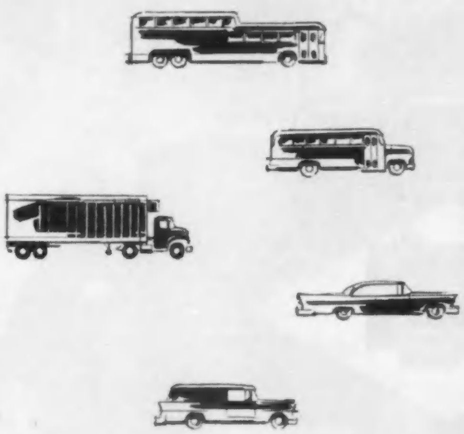
Call us. We're ready to serve you.

McQUAY-NORRIS

MANUFACTURING COMPANY **St. Louis · Toronto**

Largest Producer of Small Rings in the Automotive Industry

Specify Muskegon design for '58 and '59



Here's Why -

Piston rings must keep pace with your 1958-1959 engine developments—and Muskegon meets this challenge these three ways:

1) METALS: New compositions may be required. Muskegon metallurgists cooperate closely with you in developing them. You'll work with the engineers responsible for many famous piston ring firsts, such as sintered powdered metal rings, "Unitized" steel oil rings, chrome plated "Unitized" oil rings and lapped chromium plated steel segments.

2) DESIGNS: Muskegon engineers design piston rings to meet the exact requirements of every piston groove. This precise engineering has put Muskegon piston rings in more than one out of every three new cars on the road today.

3) PRODUCTION: Regardless of how many piston rings you may need, Muskegon stands ready to meet your requirements, when you need them. And, Muskegon is also equipped to produce your service ring sets completely packaged with your own label . . . plus rings for transmissions, power steering and air conditioning compressors.

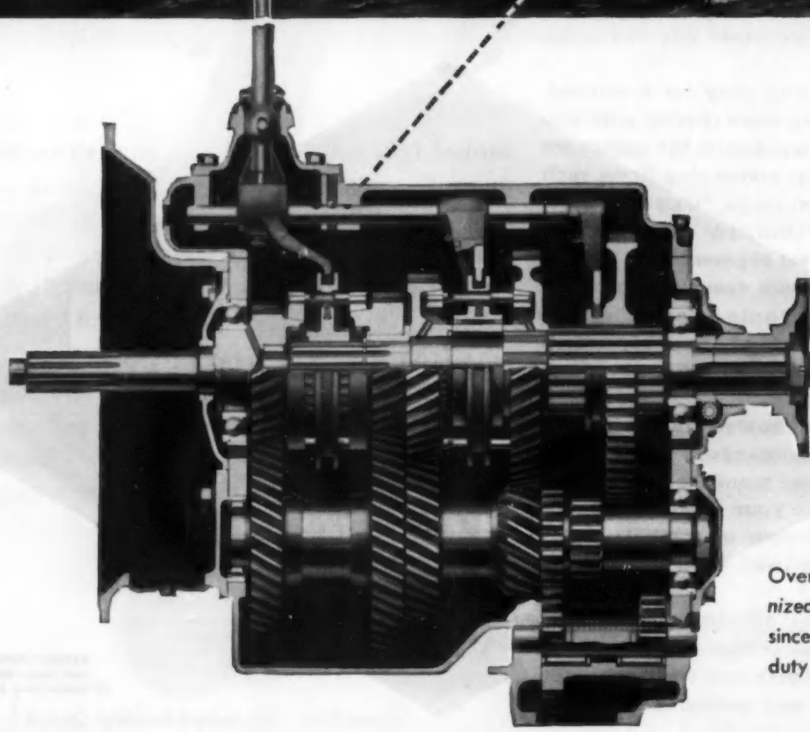
Metals, designs, production—it all adds up to the best piston rings ever for your better-than-ever 1958-1959 engines. So . . . let Muskegon plan and work with you now . . . for better design and performance in the years ahead.

MUSKEGON Piston Ring Co.

PLANTS AT MUSKEGON, MICHIGAN SPARTA, MICHIGAN
ROTARY SEAL DIVISION PLANTS AT SPARTA, MICHIGAN CHICAGO, ILLINOIS

DETROIT OFFICE: New Center Bldg. Telephone: Trinity 2-2113

Since 1921... The engine builders' source!



Over 275,000 Spicer *Fully Synchronized* Transmissions have been built since 1934 for every kind of heavy-duty civilian and military use!

DANA CORPORATION • Toledo 1, Ohio

WASTE NOT, WANT NOT

Or how Cleve-Weld circular parts know-how can save you money...

From simple gear blanks to special alloy jet rings, material is no problem. We've worked with everything from carbon steel to titanium and the newest aircraft alloys. Many of today's leading jet engine manufacturers use *Cleve-Weld* rings for this reason.

Before you specify a casting or forging for a circular part, check CLEVE-WELD. We'll have our designers, metallurgists and production men study your drawings to see if we can save you money. Call—or write and send drawings to Circular Welded Parts Department, Cleveland Welding Division, W. 117th Street and Berea Rd., Cleveland 11, Ohio.

Another AMF Product

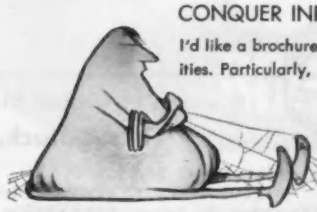
CLEVE-WELD PROCESS

RIMS · RINGS · WELDMENTS

CLEVELAND WELDING DIVISION

AMERICAN MACHINE & FOUNDRY COMPANY

Cleveland 11, Ohio



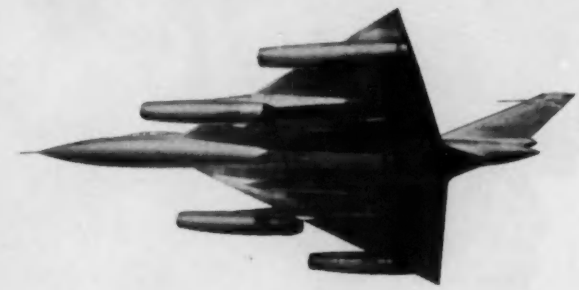
CONQUER INERTIA...MAIL THIS COUPON NOW! SAE-705

I'd like a brochure on Cleve-Weld's metallurgical, design and production facilities. Particularly, I'd like to know how the Cleve-Weld Process can cut costs.

NAME________________________

TITLE________________________

ATTACH TO YOUR COMPANY LETTERHEAD AND MAIL TODAY!



MORE AND MORE

MAJOR COMPONENTS

ARE BUILT BY ROHR

For example, brazed, stainless steel, honeycomb panel structures are being manufactured by Rohr for the great new B-58 Hustler, built by Convair for the U. S. Air Force.

Today Rohr manufactures over 30,000 airplane parts, included in such major components as stabilizers, elevators, fuselage sections, pneumatic system components, high strength weldments, and stainless steel honeycomb sandwich panels.

More and more, leading air-frame manufacturers count on Rohr for design engineering, for conception, development and production of parts to meet modern flight problems. In many cases, Rohr engineering teams are actually assigned to the customer's plant, to work with the manufacturer's engineering staff and bring back a full understanding of requirements to be met.

And, of course, Rohr is well known as the world leader in production of ready-to-install power packages for airplanes – including the Boeing B-52, KC-135, 707, Convair 880, Lockheed Electra Propjet, Super Constellation, C-130, Douglas DC-7 – and many other of America's leading military and commercial planes.

For the aircraft parts you need, next time look to Rohr.

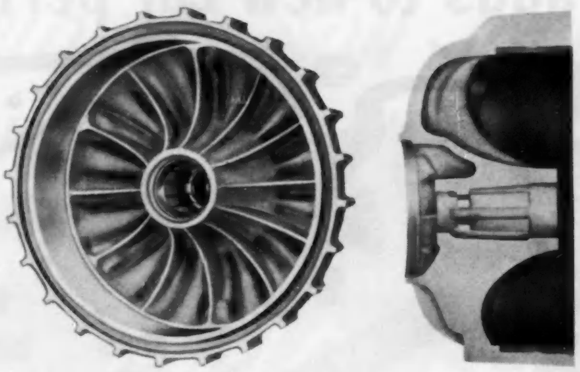
WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POWER PACKAGES FOR AIRPLANES

ROHR
AIRCRAFT CORPORATION

Excellent career openings now for engineers and tooling technicians.

CHULA VISTA, CALIFORNIA

Also plants in Riverside, California • Winder, Georgia • Auburn, Washington



Superior braking performance
Economical production by die or permanent mold casting methods
Reduced unsprung weight: 50 pounds per car
Greater mechanical strength

The new CYCLON BEARING was developed to bridge the wide separation between babbitt and heavy duty copper-lead from the standpoint of fatigue resistance and crankshaft wear. The price advantage over heavy duty copper-lead is considerable.

The research and engineering staff at Detroit Aluminum and Brass Corporation have successfully completed performance and endurance tests—the equivalent of over 2-million miles. Results show that CYCLON is as important a contribution to bearing design as the thin babbitt bearing which also was created and developed by Detroit Aluminum and Brass engineers.

The new "CYCLON" is now available for original equipment use and engine manufacturers are invited to determine the superior qualities of the CYCLON through their own testing procedures.

DETROIT ALUMINUM &

see next page for
salient features of the
CYCLON engine bearing

& BRASS CORPORATION

The new Wooldridge "Cobrahaul" Rear Dump Unit with Fuller 9-speed R-1150 ROADRANGER Transmission.

FULLER R-1150 ROADRANGER® Transmission standard on new Wooldridge "Cobras"!

The Fuller 9-speed R-1150 ROADRANGER Transmission is *standard equipment* in the new Wooldridge 35-ton, 275 hp diesel "Cobrahaul" Dumper and 26-yard 300 hp diesel "Cobra Quad" Scraper. Haul speeds exceed 32 miles an hour on the big 63,400 lb. unit.

Throughout the complete Wooldridge line . . . from the giant 41-yard scrapers down to and including the 7.5-to-10-yard "Cobrette," Fuller Transmissions are standard on Wooldridge Scrapers and hauling units.

Why? Only the most rugged, dependable transmissions can take the terrific shock loads—sudden starts—stops—torque reversals found in all kinds of off-highway operations from solid rock hauling to soggy swamp jobs.

Fuller Transmissions provide maximum ease of shifting ratios for faster acceleration and long life required for these operating conditions.

In Wooldridge's "Cobrahaul" and "Cobra Quad," the Fuller R-1150 ROADRANGER Transmission offers these additional advantages:

- **No gear splitting—9 selective gear ratios evenly and progressively spaced**
- **Easier, quicker shifts—38% steps between ratios**
- **One shift lever controls 9 forward and 1 reverse speeds**
- **Engines work in peak hp range with greater fuel economy**
- **Less driver fatigue—⅓ less shifting**
- **Range shifts pre-selected—automatic and synchronized**

From over 110 models available for rubber-tired equipment, there's a Fuller Transmission designed to do your job.

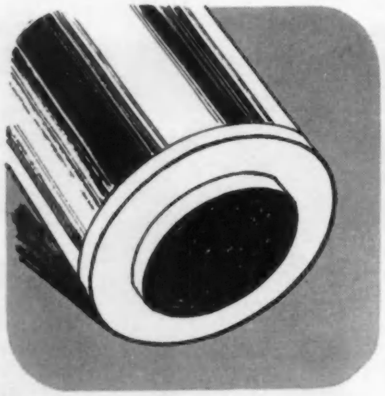
where horsepower *really* goes to work

Fuller TRANSMISSIONS

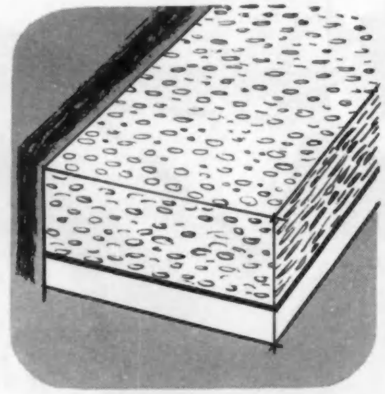
FULLER MANUFACTURING COMPANY (Transmission Division), KALAMAZOO, MICHIGAN

Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest Dist. Office, Tulsa 3, Okla.

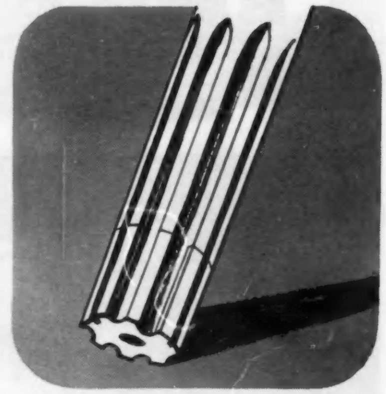
NOW—improved production through faster and better bonding with R/M Ray-BOND® Adhesives



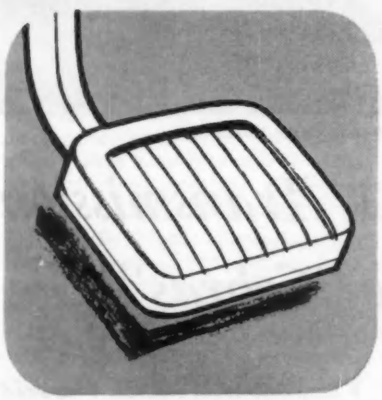
Butyl rubber foot to stainless steel tank



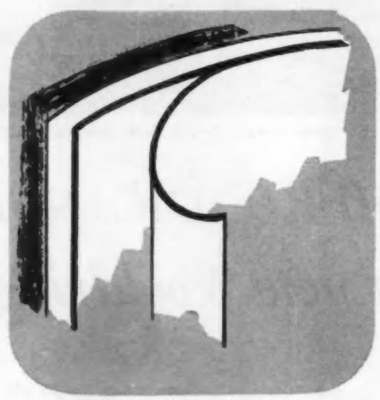
Synthetic foam to metal



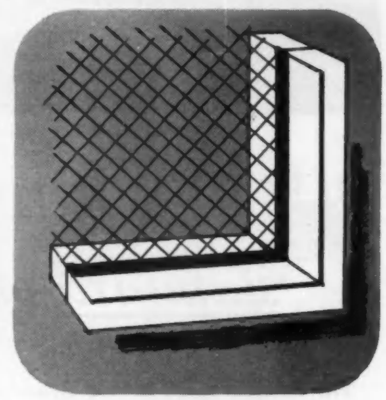
Ceramic tips to steel shanks



Natural rubber to clutch pedal



Etched "Teflon"* to steel



Rubber seals to stainless steel screens

FOR THESE AND COUNTLESS OTHER APPLICATIONS

NEW R/M Ray-BOND ADHESIVES CAN BE TAILORED TO YOUR NEEDS

Whether or not bonding, laminating, sealing or coating are now factors in your operations, the new specialized line of R/M Ray-BOND adhesives, protective coatings, and sealers may have important advantages for you. Shown above are a few of thousands of applications where use of modern bonding techniques can simplify and improve product design and eliminate troublesome fastening problems.

*A Du Pont trademark

R/M initiated the production of bonded assemblies more than 20 years ago. Over the years we have acquired a wealth of experience that can help you cut costs and simplify operations in innumerable bonding applications. Call on our engineers to work with you in developing adhesives, protective coatings, and sealers to meet your specific requirements. Adhesives Department, RAYBESTOS-MANHATTAN, INC., Bridgeport, Conn.

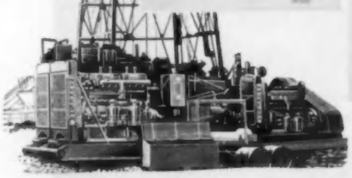
Send for free copy of R/M Bulletin No. 650A, containing engineering information on Ray-BOND adhesives, protective coatings, and sealers.

RAYBESTOS-MANHATTAN, INC.

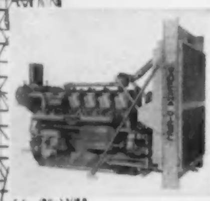
ADHESIVES DEPARTMENT: Bridgeport, Conn. • Chicago 31 • Detroit 2 • Cleveland 16 • Los Angeles 58

FACTORIES: Bridgeport, Conn.; Manheim, Pa.; Passaic, N.J.; No. Charleston, S.C.; Crawfordsville, Ind.; Neenah, Wis.; Raybestos-Manhattan (Canada) Limited, Peterborough, Ontario, Canada

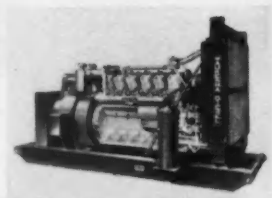
RAYBESTOS-MANHATTAN, INC., Industrial Adhesives • Brake Linings • Brake Blocks • Clutch Facings • Industrial Rubber • Engineered Plastics • Sintered Metal Products Rubber Covered Equipment • Asbestos Textiles • Laundry Pads and Covers • Packings • Abrasive and Diamond Wheels • Bowling Balls



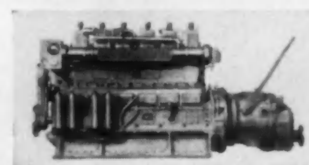
Model VLRDBS



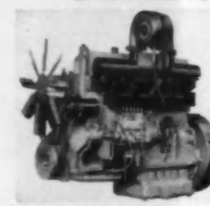
700 KW Enginator



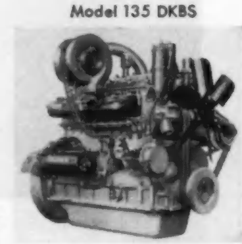
Marine LRDB



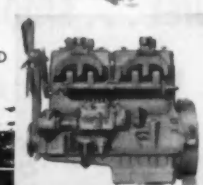
Model WAKDBS



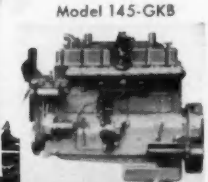
Model 135 DKBS

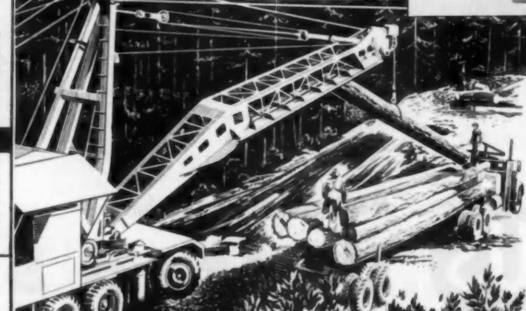


Model WAKD



Model 145-GKB

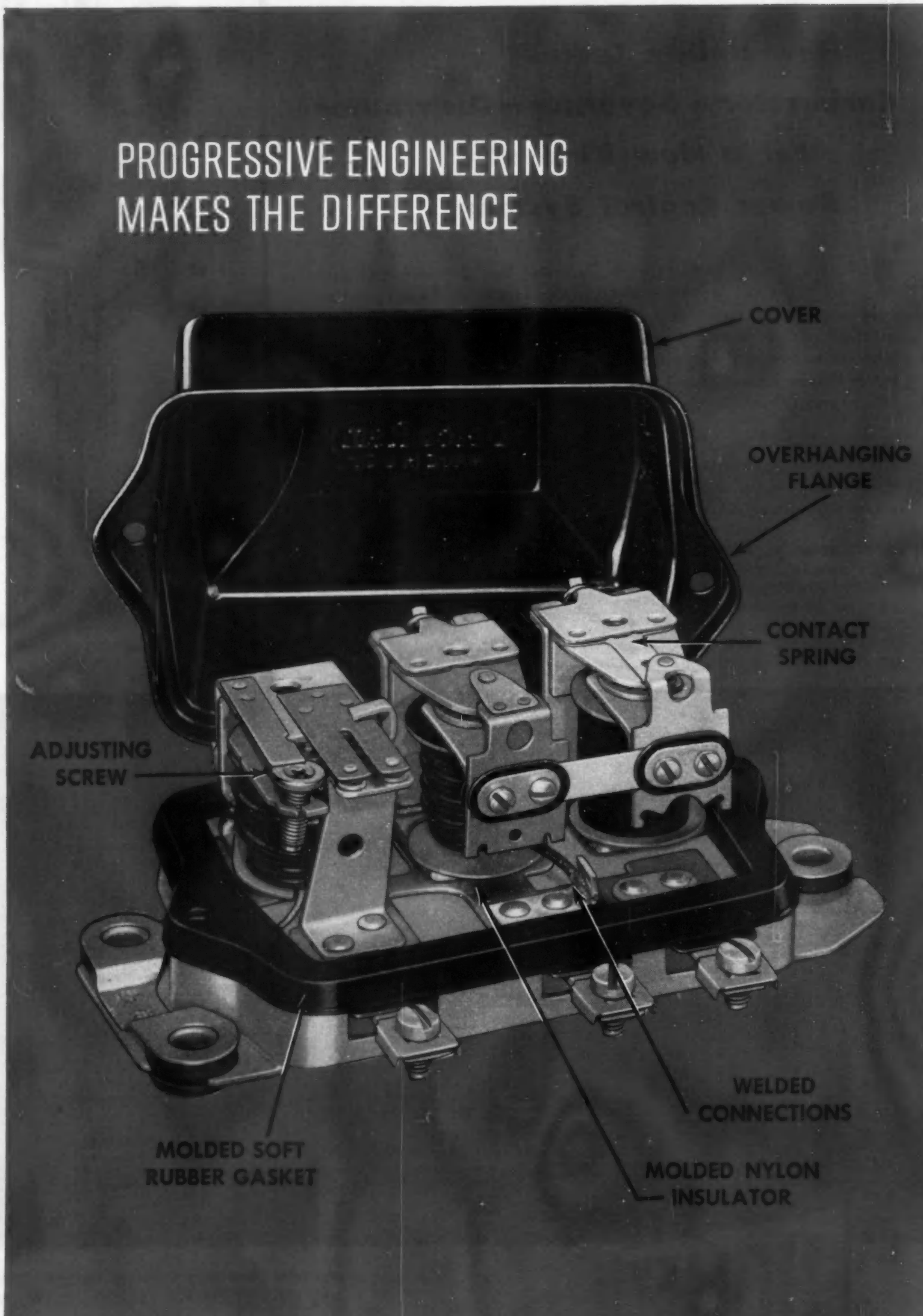




Displ. Cu. In.	Bore and Stroke	Standard Crankshaft		Counterbalanced Shaft		Features*
		Model	HP @ RPM	Model	HP @ RPM	
NORMAL DIESEL ENGINES						
144	3½x3¾	....	....	180-DLC	45 @ 2400	4AOW
216	3½x3¾	185-DLC	60 @ 2400	....	....	6AOW
265	3¾x4	190-DLC	84 @ 2400	190-DLCA	85 @ 2800	6AOW
302	4 x4	195-DLC	96 @ 2400	195-DLCA	98 @ 2800	6ADO
426	4¼x5	135-DK	140 @ 2400	135-DKB	147 @ 2800	6ADO
779	5¼x6	148-DK	169 @ 1600	148-DKB	200 @ 2100	6AOW
1197	6¼x6½	WAKD	220 @ 1500	WAKDB	258 @ 1800	6AOW
1905	7 x8¼	....	....	NKDB	297 @ 1200	6AOW
2894	8½x8½	....	....	LRDB	415 @ 1200	6AOW
5788	8½x8½	....	....	VLRDB	830 @ 1200	12AOW
TURBOCHARGED DIESEL ENGINES						
426	4¼x5	....	....	135-DKBS	185 @ 2800	6ADO
779	5¼x6	....	....	148-DKBS	280 @ 2100	6AOW
1197	6¼x6½	....	....	WAKDBS	352 @ 1800	6AOW
1905	7 x8¼	....	....	NKDBS	390 @ 1200	6AOW
2894	8½x8½	....	....	LRDBS	570 @ 1200	6AOW
5788	8½x8½	....	....	VLRDBS	1135 @ 1200	12AOW
GASOLINE, GAS ENGINES						
61	2½x3⅛	ICK	18 @ 3200	....	....	4ILN
133	3¼x4	FC	34 @ 2600	....	....	4ILN
144	3½x3¾	....	....	180-GLB	45 @ 2400	4AOW
186	3⅝x4½	XAH	47 @ 2200	....	....	4ILN
216	3½x3¾	185-GLB	67 @ 2400	....	....	6AOW
265	3¾x4	190-GLB	77 @ 2400	....	....	6IOW
302	4 x4	195-GL	85 @ 2400	....	....	6DIO
320	4⅛x4	195-GK	103 @ 2400 (I)	195-GKA	122 @ 3000 (F)	6ANO
404	4¼x4¾	MZA**	128 @ 2800 (F)	....	....	6ALN
426	4¼x5	135-GK	134 @ 2400	135-GKB	147 @ 2800 (F)	6ADO
451	4⅜x5	135-GZ	143 @ 2400	135-GZB	153 @ 2800 (F)	6ANO
525	4½x5½	140-GK**	160 @ 2250 (F)	140-GKB	177 @ 2600 (F)	6AOW
554	4⅝x5½	140-GZ	168 @ 2250 (F)	140-GZB	188 @ 2600 (F)	6AOW
779	5¼x6	145-GK**	216 @ 2000 (F)	145-GKB	240 @ 2400 (F)	6AOW
817	5⅜x6	....	....	145-GZB	250 @ 2400 (F)	6AOW
1197	6¼x6½	WAK	222 @ 1600	WAKB (A)	280 @ 1800	6IOW
GAS ENGINES						
1197	6¼x6½	WAKR	290 @ 1800	WAKB	300 @ 1800	6AOW
1905	7 x8¼	....	....	NKRB	325 @ 1200	6AOW
2894	8½x8½	....	....	LRORB	465 @ 1200	6AOW
3520	9⅜x8½	....	....	LRZB	594 @ 1200	6AOW
5788	8½x8½	....	....	VLROB	900 @ 1200	12AOW

* **Features:** 4, 6, 12-Number Cylinders, A-Aluminum Pistons, D-Dry Sleeves, I-Iron Pistons, L-L-head, N-No Sleeves, O-Overhead Valves, W-Wet Sleeves.
** Also, with iron pistons for low speed service. (F)-Rated higher for fire service.

343


PROGRESSIVE ENGINEERING
MAKES THE DIFFERENCE
COVER
OVERHANGING FLANGE
CONTACT SPRING
ADJUSTING SCREW
WELDED CONNECTIONS
MOLDED SOFT RUBBER GASKET
MOLDED NYLON INSULATOR

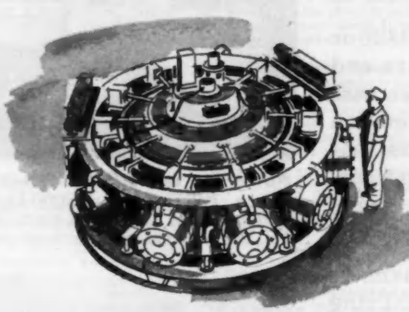
"On a half-million car year,

we'd save over $88,000!"

"Here's where we can save some money, Charlie ... on wrist pin bushings. We can buy bronze or aluminum for about the same price per pound. But we get three times as many bushings out of a pound of aluminum. It figures out to a savings of over 2¢ per bushing. On an 8-cylinder car, we save about 17¾¢. If we have a half-million car year, that's $88,750. Not bad!"

Wrist pin bushings of Alcoa® Aluminum *are* the key to important savings. To mean something, these savings have to be achieved at no sacrifice in performance. Modern engines must be capable of turning over much faster to meet advertised horsepower ratings. It has been estimated that the pressure on the wrist pin bushings can be as high as 8,000 to 10,000 psi.

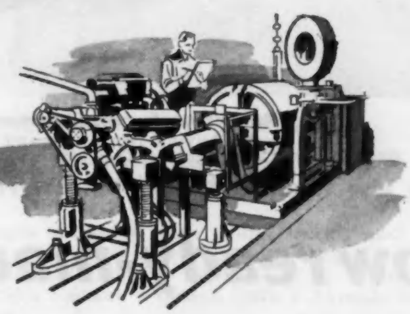
Can aluminum take this pounding and hold up? You bet! No other bushing material is in the same league with aluminum for load-carrying capacity. Aluminum bearings are first choice for the really heavy-duty services such as diesel engines. They last 20,000 hours and more in this tough service.



Nordberg Manufacturing Company now uses aluminum wrist pin bushings in one of their diesel engines. Performance on all counts has been superb.

Aluminum is an ideal wrist pin bushing material. It runs cool because of its excellent thermal conductivity. There's little likelihood of seizure with aluminum bushings. It is a very ductile metal and conforms easily to misalignment or nonparallelism.

There's no corrosion problem with aluminum bushings. Additives in oil can't hurt it. No protective coating is necessary. Aluminum is an easy material to fabricate. All operations may be performed with readily available, standard tools.



As part of the development program, Alcoa engineers ran actual tests on aluminum wrist pin bushings installed in engines. In one test, a 1955 engine was equipped with aluminum bushings and run on a dynamometer on a breakdown schedule. Performance was excellent. Wear rates were equal or superior to those obtained with other materials.

If you haven't already begun an investigation of this important means of saving cost at no sacrifice in performance, we suggest that you do so. Alcoa stands ready to offer full assistance to manufacturers who want to take advantage of aluminum's many excellent qualities. Our Development Division will work with you on the goals you've set for your new models. Aluminum Company of America, 1844-E Alcoa Building, Pittsburgh 19, Pennsylvania.

ALCOA ALUMINUM gives every 1957 car more **GLEAM AND GO**

"Rhino" meets rugged demands of line maintenance work. Driving front axle and other vital parts made from nickel alloy steels. The "RHINO" is produced by The Four Wheel Drive Auto Co., Clintonville, Wisc.

Driving safety boosted in new pumper series. Steering made easier, cornering improved. FWD toughens components by making them of nickel alloy steels.

How ready-made steels boost ratings

9500 POUNDS . . . that's the rating of the live front axle on this FWD "Rhino." Stronger than the usual truck axle by 50%, it safely takes stress and strain from front-mounted derrick and digger.

Built to handle work far beyond the scope of a conventional truck, FWD vehicles need extra stamina, obviously. And to obtain it, FWD's engineers specify standard grades of nickel alloy steels. Grades that show how you, too, may boost ratings.

For example, nickel-chromium-molybdenum axle shafts of 4337 and main transmission shafts of 4340 withstand shocks, fatigue and multiaxial stresses. Furthermore, these steels readily respond to fabrication and heat treatment.

Carburizing grades . . . 4820 or 4620 for transmission gears, and 4620 or 8720 for transfer case gears . . . provide the combination of strength and toughness that means hard, wear-resistant surfaces supported by strong, tough, shock-resistant cores.

For extremely high toughness and strength in differential ring gears and pinions, FWD specifies Krupp 4% nickel 1½% chromium steel.

Whatever your product, when you face questions about metal let us give you the benefit of our wide practical experience. Write for List A of available publications. It includes a simple form that makes it easy for you to outline your problem.

Power to spare in roughest kind of going. FWD road maintenance trucks utilize nickel alloy steel parts for essential stamina as well as wear-resistance.

One-man cab unit allows 10% more cargo space. Thanks to weight-saving rear axles and scientific weight distribution. Strength gained by using nickel alloy steels permits the extra payload.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.

air-conditioned cover keeps new clutch c-o-o-l

Frictional heat has little effect on the new *Lipe* Direct Pressure Clutch. Air circulating through the cover's 33 ventilating holes dissipates heat rapidly. The result is a heavy-duty clutch singularly free of burned facings and warped pressure plates. A clutch whose low maintenance cost matches its low first cost.

Lipe Direct Pressure Clutches now available: 13", 14", 15" single-plate, 14" and 15" two-plate. Send for complete information.

For the name of your nearest Authorized Lipe Distributor, look under "Clutches" in your telephone directory. Or, write us.

Manufacturers of Automotive Clutches & Machine Tools

LIPE ROLLWAY

Lipe-ROLLWAY CORPORATION
SYRACUSE 1, N. Y.

YOUR CAR'S "FOUL WEATHER FRIEND!"

What did winter weather do to *your* car? If the "brightwork" isn't stainless steel, chances are it took its toll in pitting and dents from salted and cindered roads — and corrosion from heavy winter moisture.

Stainless steel is the ounce of prevention — and the pound of beauty — that eliminates all this. For nothing stands up to bad weather like stainless. In foul weather or fair, it's the metal that comes up bright and shining with mere soap-and-water washing. Road chemicals don't change its solid, gleaming characteristics. It even resists denting.

That's why stainless means so much more than showroom beauty. Car buyers know that stainless steel — in trim and in critical parts — stays useful and attractive for the *life of the car*. Stainless keeps *re-sale* values up, too.

Investigate the benefits and economies of stainless steel in automotive uses. You'll learn that the finest stainless steels are made with Vancoram Ferro Alloys. Your steel supplier can give you valuable facts about how enduring stainless steel can mean added value and beauty in the automobiles you make — and use.

VANADIUM CORPORATION OF AMERICA

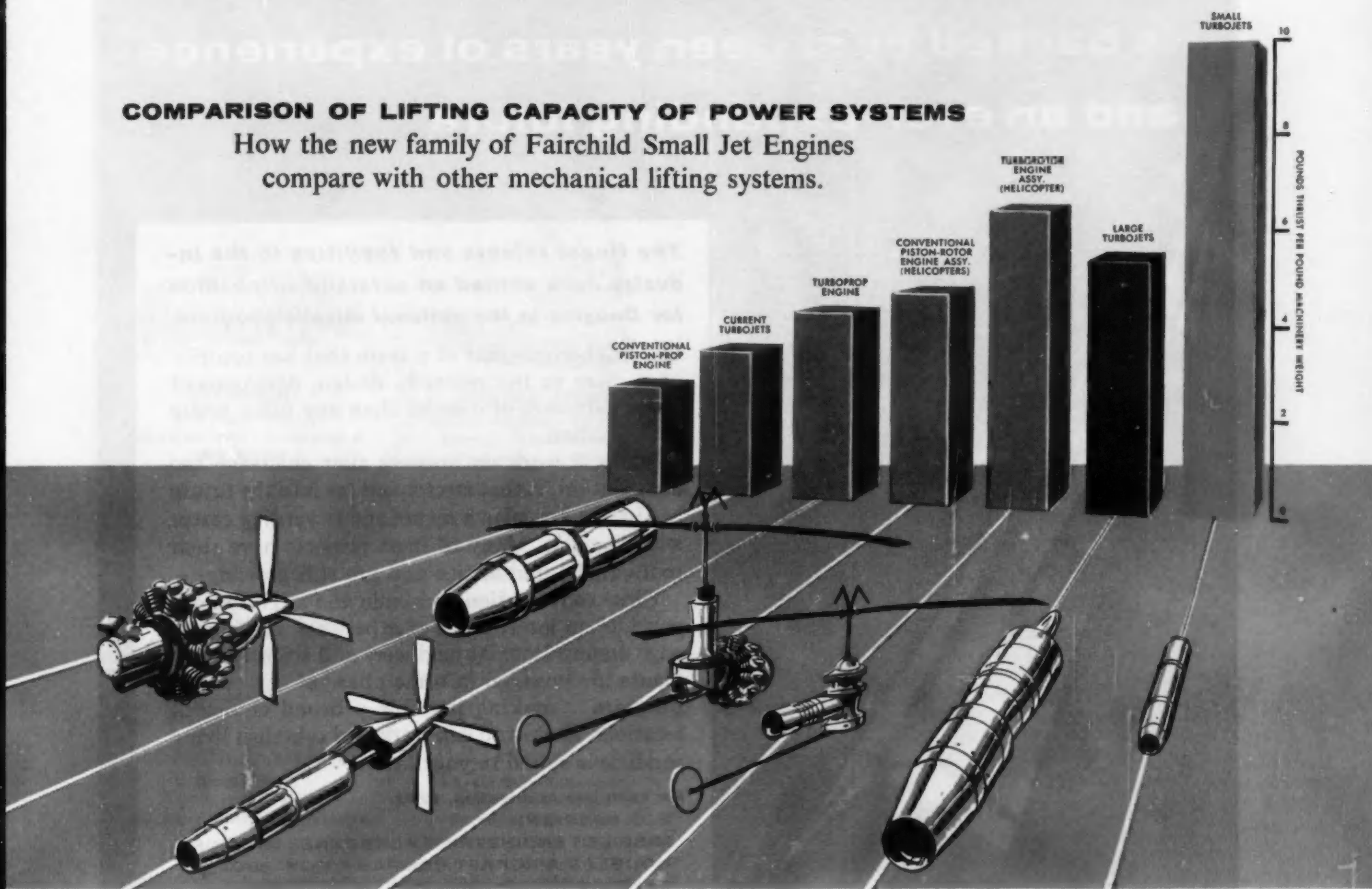
420 Lexington Avenue, New York 17, N. Y. • Chicago • Cleveland • Detroit • Pittsburgh

Producers of alloys, metals and chemicals

SMALL JET ENGINES . . . CHAMPION WEIGHT LIFTERS

COMPARISON OF LIFTING CAPACITY OF POWER SYSTEMS

How the new family of Fairchild Small Jet Engines compare with other mechanical lifting systems.



An entirely new family of aircraft will evolve from a new family of small lightweight jet engines now under development at the Fairchild Engine Division. These new powerplants will feature incredibly high thrusts and great lifting power . . . yet will be so light they can easily be carried by two men.

Highly compact, with low frontal areas, the small jet engines will deliver thrust/weight ratios starting at 8 to 1 with a long range potential of more than 10 to 1. They will be used in the high performance, lightweight trainers, interceptors, target drones, pilotless aircraft including missiles and intermediate class passenger and cargo jets of the nineteen sixties. They will also be used to power fighters and utility cargo craft, executive aircraft . . . and will make jet Short Take Off and Landing (STOL) and Vertical Take Off and Landing (VTOL) aircraft practical.

The small jet engine may be used singly, in pairs and in clusters. It provides multi-engine reliability in aircraft of a size now wholly dependent on a single engine. The small jet engine will produce greater versatility and utility in airplanes of tomorrow.

The extensive research facilities at Fairchild Engine Division have been designed solely to test performance of the small jet engine. They range from full scale, high altitude test chambers to supersonic research for component design. Fairchild Engine Division has spent a decade in the design, development and production of small, powerful jet engines.

FAIRCHILD
ENGINE DIVISION
DEER PARK, LONG ISLAND, N. Y.
A DIVISION OF FAIRCHILD ENGINE AND AIRPLANE CORPORATION

. . . WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!

A Boeing B-47 Stratojet medium bomber gets a take-off assist from 30 Phillips Petroleum Company M15 JATOs.

N-A-X HIGH-TENSILE is readily formed and welded. Here, before welding, a worker sizes the container's aft head, drawn by a 250-ton press. Bottom forging is locked in.

N-A-X HIGH-TENSILE STEEL FORMS AND WELDS READILY

Formability: Even at the higher strength levels (50% greater than mild carbon steel) this material can be cold formed and drawn into very difficult stampings and cold formed shapes.

Weldability: Its weldability by any process is excellent, maintaining toughness through a wide range of temperatures. Under-bead cracking tests are excellent. Using American Welding Society standard bead-weld testing, shows under-bead hardness rises only to 95 Rockwell from 80-85 Rockwell prior to welding.

IMPORTANT DEVELOPMENTS AT JPL

Development of Vehicle Design

The Jet Propulsion Laboratory is a stable research and development center located north of Pasadena in the foothills of the San Gabriel mountains. Covering an 80 acre area and employing 1700 people, it is close to attractive residential areas.

The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U.S. Government.

Opportunities open to qualified engineers of U.S. citizenship. Inquiries now invited.

Recognizing the need for information regarding the transfer of loads from vehicles to elements of highly-mobile missile systems, engineers at JPL undertook to obtain this vital information.

For the first time, with specially designed vehicles tested on rough terrain under the severest operating conditions and using the most modern instrumentation techniques, significant results have been obtained.

These data, when combined with the results of computer studies and analysis have now provided the genesis of more realistic design load criteria—the first available.

Application of this new knowledge now makes possible the design of vehicular equipment having greater stamina and of much lighter weight.

Recognition of the need for such types of information and the subsequent follow-thru to obtain it, is typical of the Laboratory's attack on problems that need solving. That JPL has been so successful in these activities is largely due to the fact that its engineers are given complete design responsibility and freedom of action and decision.

Send your resume today if you are interested in this type of research activity.

JOB OPPORTUNITIES IN THESE FIELDS NOW

jpl

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JET PROPULSION LABORATORY

A DIVISION OF CALIFORNIA INSTITUTE OF TECHNOLOGY

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HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting spring tension in the flexible locking collars. And they are reusable: rough screw threads, repeated removal and replacement, frequent adjustments will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes and materials, to meet the most critical locknut requirements. Your authorized industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 55, Pa.

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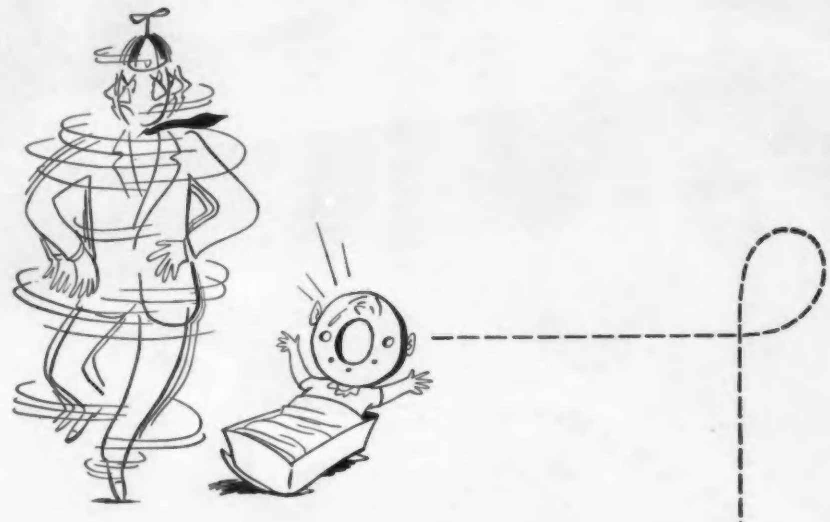
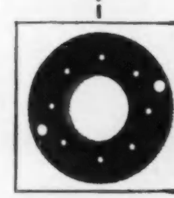
SPS

JENKINTOWN PENNSYLVANIA



a FRETTING-CORROSION problem had him in a spin



Finding a wear-resistant coating for turbine engine shaft seals posed a serious problem for an aircraft engine manufacturer. Even the hardest alloys were subject to fretting-corrosion and had to be replaced after a few hours of service.

This fretting-corrosion problem was solved by having the bearing surface of the seal Flame-Plated by LINDE. By this special detonation process, particles of tungsten carbide are literally *blasted* onto almost any metal surface. Most important, the temperature of the part being plated never exceeds 400° F., so there is little chance that the base metal will warp or that its metallurgical properties will be changed. Flame-Plated tungsten carbide coatings can be applied in thicknesses from .010 to .002 inches. Coatings can be used in the as-coated condition (125 microinches rms) or ground and lapped to a 0.5 microinch finish.

If your design involves metal parts subject to extreme wear, heat, or fretting-corrosion, perhaps Flame-Plating can eliminate some or all of your "headaches"—or make possible some completely new idea.

To find out, write us about your wear problem or request a free copy of LINDE's booklet, "Flame-Plating," F8065. Address Flame-Plating Department.

Flame Plating by *Linde*

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A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, New York

In Canada: Linde Air Products Company, Division of Union Carbide Canada Limited, Toronto

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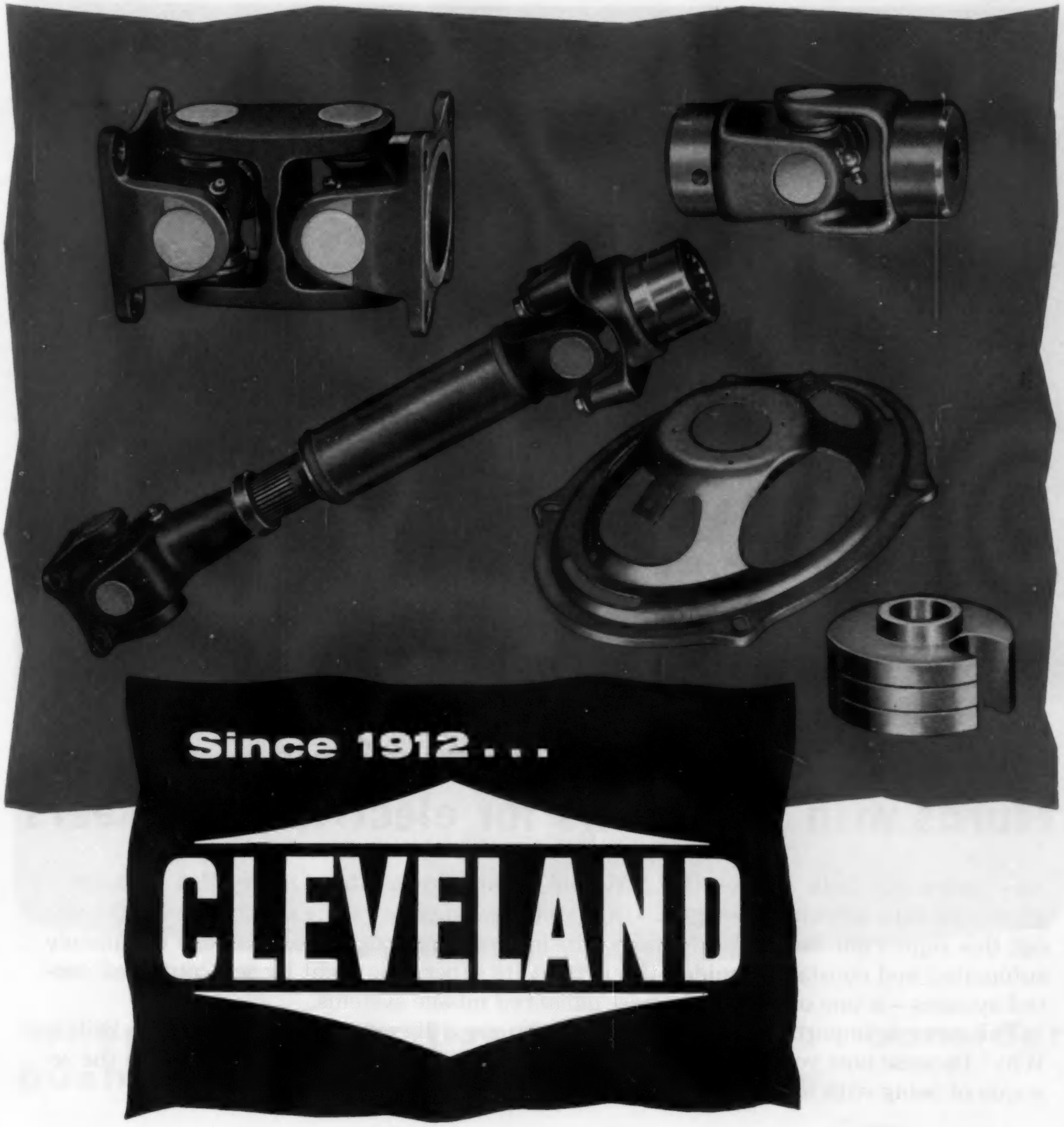

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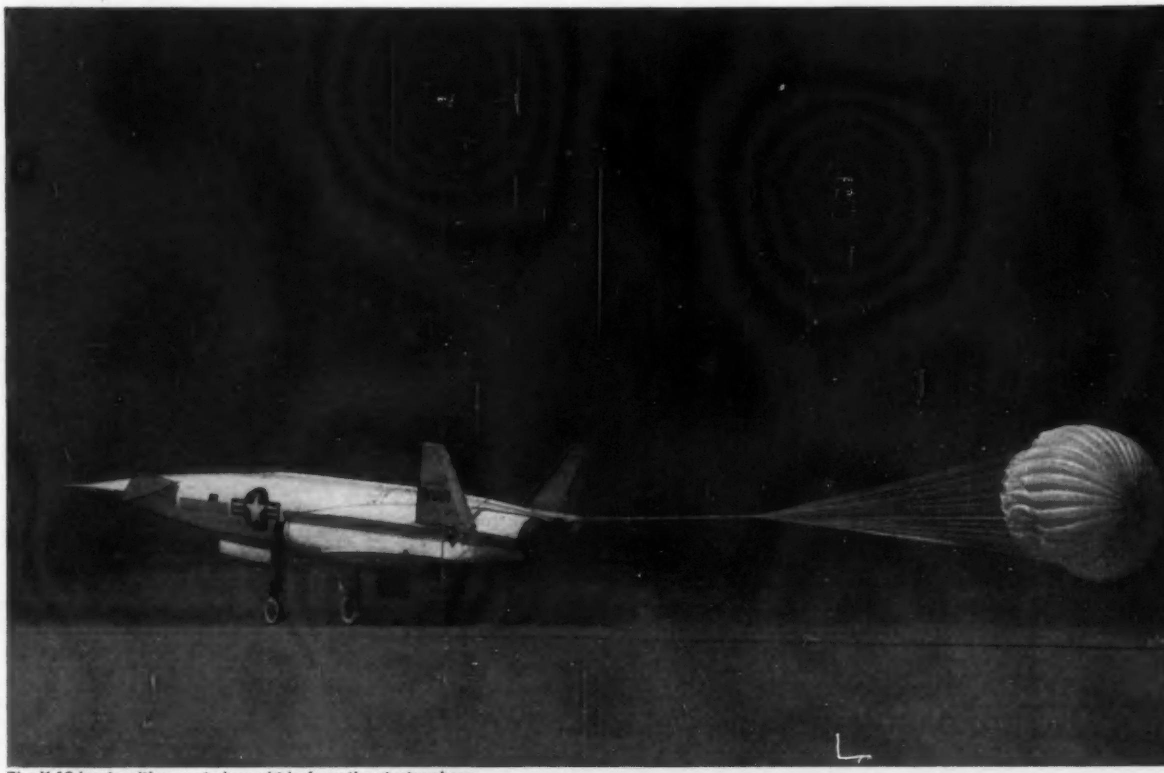


The X-10 lands with secrets brought in from the stratosphere.

X-10 missile test vehicle returns with good news for electrical engineers

New scientific data allows the Navaho Missile to leapfrog many R & D steps — go direct into advanced stages. Unprecedented success of the supersonic X-10 spells out this significant fact: The Navaho — an intercontinental strategic missile completely automated and constantly guided throughout its supersonic flight by self-contained control systems — is one of America's *most advanced* missile systems.

This news is important to you — whether you are a 10-year veteran or a recent BSEE. Why? Because now you can start at the very top of missile technology — and reap the rewards of being with a years-ahead company.

40 immediate career opportunities in electronic systems analysis

In Missile Engineering you'll investigate applications of automation that are literally strides ahead of the field. You'll pursue them in pre-flight, preparation, checkout, fueling, countdown and firing. You'll work on "in-flight" control and guidance systems so precise that even the environment within the missile must be rigidly controlled.

One of our immediate needs is for electrical engineers — especially those qualified in systems analysis, systems evaluation, component design and ground checkout. No matter what your experience has been it can be useful to us.

For complete details on these — and other engineering openings — please write: Mr. R. L. Cunningham, Engineering Personnel Manager, Dept. 495SAE5, Missile Development Division, 12214 Lakewood Blvd., Downey, California.

MISSILE DEVELOPMENT DIVISION

NORTH AMERICAN AVIATION, INC.

Citroën's hydro-pneumatic suspension*

Transmission, clutch, brakes, and steering also served by centralized hydraulic system through reliable Bundyweld

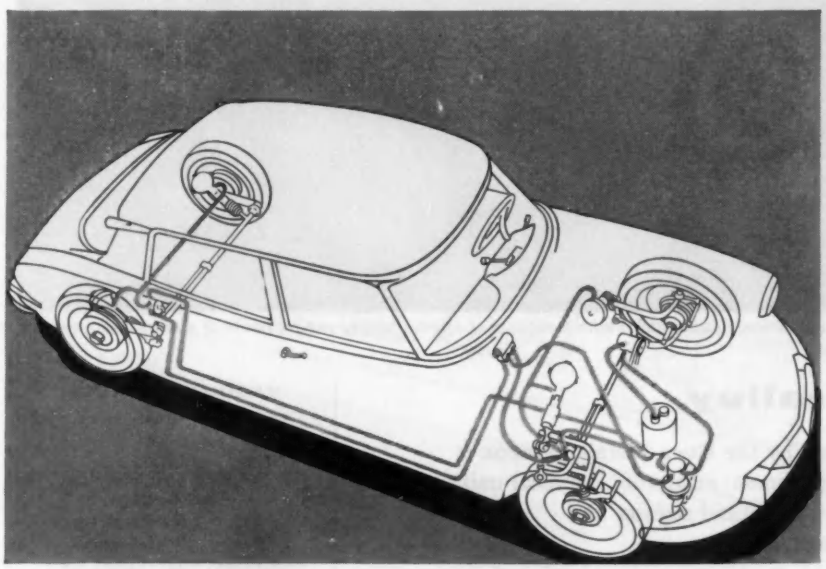
Fabulous is the word for Citroën's unique hydro-pneumatic suspension. It utilizes a combination of oil and inert gas under pressure to soak up every last jolt and jar for a cloud-soft ride. But Citroën's suspension and other power-assisted components need an unending supply of hydraulic fluid. And this is delivered unfailingly through Bundyweld Tubing®.

Ultrareliable is the word for Bundyweld Tubing. Because it is the only tubing double-walled from a single steel strip, then metallurgically bonded through 360° of wall contact, Bundyweld is amazingly strong and resistant to vibration fatigue . . . *leakproof by test.*

This same exclusive process gives Bundyweld high bursting strength and tensile strength . . . makes it smooth, ductile and easy to fabricate, even in the most complex shapes. These properties are the reasons *Bundyweld is used on 95% of today's cars, in an average of 20 applications each!*

Whether you want tubing straight, coiled, or fabricated precisely to specification, Bundy® will handle the job. Your tubing will be packaged carefully, delivered right on schedule — clean, bright and ready to use. And Bundy offers free, expert engineering service as well. Need tubing for mechanical or fluid transmission applications on cars, trucks, or farm equipment? Chances are you'll save time and money by checking first with Bundy. Call, write, or wire us today!

BUNDY TUBING COMPANY • DETROIT 14, MICHIGAN



Heart of Citroën's centralized hydraulic system is a high-pressure, 7-piston pump which drives hydraulic fluid into a constant-pressure accumulator. From there, it feeds through dependable Bundyweld Tubing to the suspension, shown in schematic diagram at left. Other power-assisted components: *Clutch* — standard-type automatically disengages when gearshift is moved, or engine rpm's fall to idling. *Transmission* — manual shift actuates hydraulic-assisted selector forks. *Brakes* — two separate Bundyweld lines supply front disc brakes and rear drum brakes. *Steering* — hydraulic cylinder moves standard rack and pinion either way on demand.

**Citromatic®*

BUNDYWELD® TUBING

Bundy Tubing Distributors and Representatives: ***Bala-Cynwyd, Pa.:*** Rutan & Co., 1 Bala Ave. • ***Cambridge 42, Mass.:*** Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Dallas, Texas:*** Vinson Steel & Aluminum Co., 4606 Singleton Blvd. ***Los Angeles 22, Calif.:*** Pacific Metals Co., Ltd., 2187 S. Garfield • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** • Eagle Metals Co., 4755 First Ave., South.

Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, GERMANY, AND ITALY


SKF CAN EQUIP
EVERY THING THAT ROLLS
EVERY TYPE—EVERY USE
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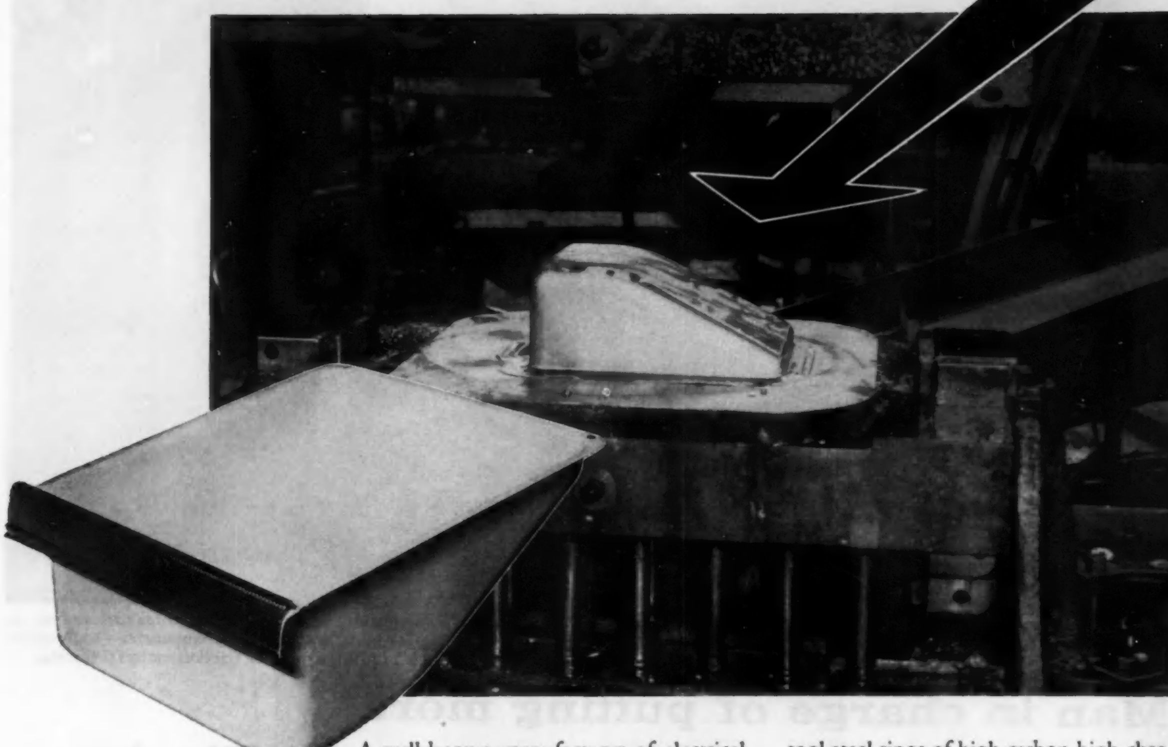
Here's how A-L CAST-TO-SHAPE TOOL STEELS solved a serious scrap problem on this job



A well-known manufacturer of electrical appliances formerly used dies of alloyed ductile iron castings to draw refrigerator crisper pans.

These dies had to be redressed after every 10,000 pieces (approximate cost: $1300 each) and had to be replaced after every 30,000 pieces. 8 to 10% of the pans were scrapped due to defects.

Because of this scrap problem and the severity of the draw—a 52% reduction of the steel—it was decided to rebuild the dies using a suitable grade of tool steel.

A 2″ cut was taken off the top of the old cavity and the draw ring. These cuts were replaced with A-L Cast-to-Shape tool steel rings of high carbon-high chromium analysis. Total cost was nominal compared with buying entirely new dies.

Each of the revised dies has produced approximately 500,000 pans. Their condition indicates that probably *twice* that many can be drawn before the dies must be redressed. Defective pieces have been reduced to a mere 1½ to 2%—***an 80% reduction!***

• Ask your A-L representative TODAY how Cast-to-Shape tool steel can help solve your production problems . . . or write ***Allegheny Ludlum Steel Corporation, Forging and Casting Division, Detroit 20, Mich.***

SEND FOR THIS NEW CATALOG

"FORGING AND CASTING PRODUCTS"

Contains the latest information on FCC Air Hardening, Oil Hardening and other Cast-to-Shape Tool Steel Specialties that can save you time and money . . . also Composite Die Sections and Smooth Hammered Forgings in a wide range of tool and stainless steels. *Get your copy NOW*

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A-L® FINE TOOL STEELS SINCE 1854

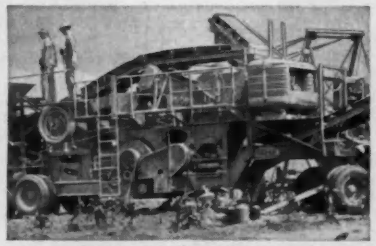
WSW 6123

More than 100 famous

THE GALION IRON WORKS MFG. CO. is a well-known maker of motor graders using International heavy-duty carbureted and diesel engines.

equipment manufacturers

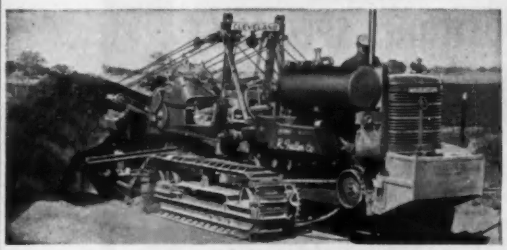
BUCYRUS-ERIE offers International engines in the broad line of shovels and construction tools the construction industry buys in volume from this famous manufacturer.



IOWA MANUFACTURING CO. makes the well-known line of Cedar Rapids crushers. Pamper-proof International diesel engines, known for high production and low maintenance, are available for their models.

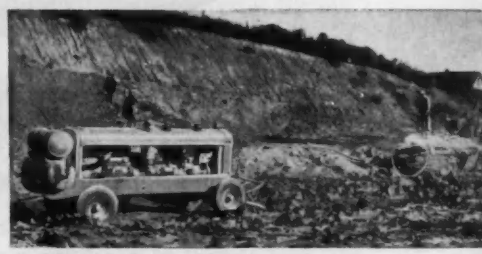
WARNER & SWASEY make the do-everything Gradall® that trenches, grades, excavates, ditches, stockpiles, lifts, and loads. This famous firm solves engine problems the sure way—with International power.

power their products with



THE CLEVELAND TRENCHER CO. makes sure their models have the power for hard digging even in frozen and rocky ground without expensive maintenance downtime by making them available with International heavy-duty 4-cycle diesel engines.

BARBER-GREENE makes a wide variety of products, including this Model 845 High Type Continuous Mix Asphalt Plant. They give customers the operating dependability and economy they prefer with International power units.



SCHRAMM is known everywhere as a compressor manufacturer and products like this Model 315 are available with International diesels to keep production high and operating costs low year after year.

International® Engines

You, too, can specify International power and get the benefits of over 55 years of heavy-duty engine design and manufacturing experience. You'll get a full measure of dependable and economical power for your customers.

Our experienced installation engineers are ready to help you with your power needs. Pilot engine models are available for your research and testing programs.

These services are only surpassed by International's world-wide service facilities in the field...anywhere. That's why more than 100 equipment manufacturers power their products with Internationals. Join these shrewd power buyers by calling or writing us today.

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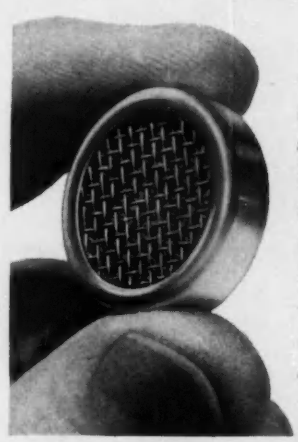
A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors... Self-Propelled Scrapers... Crawler and Rubber-Tired Loaders... Off-Highway Haulers... Diesel and Carbureted Engines... Motor Trucks... Farm Tractors and Equipment.

NEW FILTER DISC

screen disc cartridge for service as breather or flame arrester



• A new filter disc incorporating wire cloth screen as filter media is available for application to many types of products. Completely self-contained, for simple adaptation to any product design, the filter disc serves as a breather or can be used as a tank vent flame arrester. Filter media is multiple layers of fine mesh steel or bronze wire screen. Available in 1", 1⅜", 1⅝", 3½" diameters. Write for complete information. **AIR-MAZE CORPORATION**, Cleveland 28, Ohio.

In 1883, Gottlieb Daimler built the world's first high revolution gasoline engine.

In 1884, Karl Benz obtained the world's first patent for a motor vehicle.

In 1926, these two pioneering manufacturers joined in a merger to form the present Daimler-Benz A. G., Stuttgart, West Germany.

Today, Daimler-Benz builds the world's finest automobiles – the Mercedes-Benz – and produces diesel powered trucks and tractors, and diesel engines from 10 to 3000 horsepower for marine, rail and industrial uses.

The company exports from Germany to 128 foreign countries through more than 1,100 agencies and distributors and operates assembly and production facilities in 27 foreign countries.

Daimler-Benz today employs 53,000 in Germany and an additional 13,000 outside Germany.

Sales in 1956 were $392,000,000.

In 1903, Orville and Wilbur Wright flew for the first time in history with an airplane and engine of their own design. Glenn H. Curtiss pioneered in aircraft development during the same period.

In 1929, the Curtiss-Wright Corporation was formed by merging the companies founded by the Wright Brothers and Curtiss.

Today, Curtiss-Wright is a leading producer of aircraft engines, missiles, propellers, electronic flight simulators, and other aircraft equipment for the military and the commercial airlines, as well as products in the fields of electronics, ultrasonics, nucleonics, thermodynamics, plastics and metallurgy. The fastest airliners in operation today are powered by Curtiss-Wright engines. A Curtiss-Wright rocket engine powered the Bell X2 to world speed and altitude records.

Curtiss-Wright employs 32,000 in 17 divisions and subsidiaries in the United States and two foreign countries and exports products throughout the world.

Sales in 1956 were $571,000,000.

Beginning as wagon manufacturers in 1852, the Studebaker Brothers produced a 16 horsepower gasoline powered car in 1904 at South Bend, Indiana.

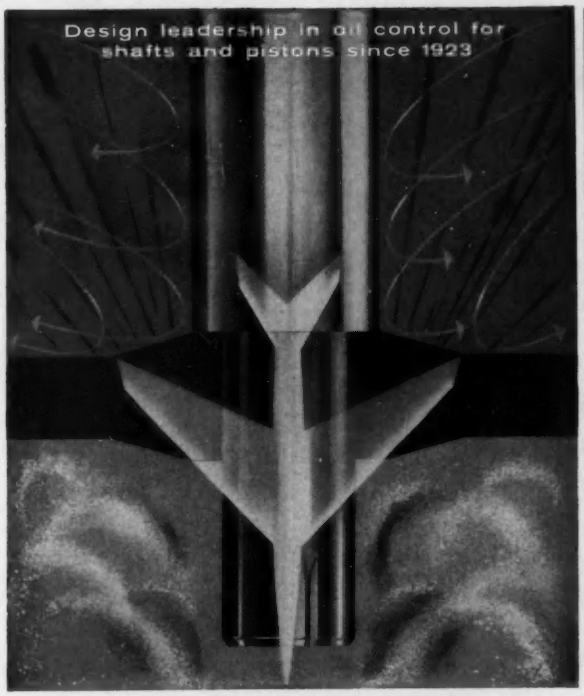
In 1899, the Packard Motor Company produced a 12 horsepower car at Warren, Ohio.

In 1954, Studebaker-Packard Corporation was formed through a combination of these two companies. Today, Studebaker-Packard Corporation manufactures a complete line of passenger cars, trucks, and station-wagons which are distributed throughout the world and sold by more than 2,400 dealers in the United States and Canada. The company pioneered modern supercharged engines, low silhouette jet styling, twin-traction rear axles, torsion springing and finned, air-cooled brakes.

The company's products are assembled in plants operating in 11 foreign countries.

Studebaker-Packard Corporation employs 9,000 at South Bend, Indiana.

Sales in 1956 were $303,000,000.



Out-of-the ordinary

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...solve them with SIMPLEX

High shaft speeds . . . high temperatures . . . special conditions . . . call for specialized help in designing suitable shaft seals.

As originators of the modern expansion ring sealing principle, SIMPLEX offers design help based on engineering leadership both in high-speed shaft seals and piston rings. SIMPLEX products are supplied as original equipment in Allison, Pratt & Whitney, Wright and other leading aircraft engines.

If your problems involve rings or seals, for jet or reciprocating aircraft engines or components, SIMPLEX can help you solve them. Call, wire or write.

Simplex Piston Ring Mfg. Co.

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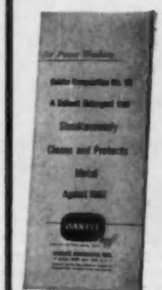
SIMPLEX
HIGH SPEED SHAFT SEALS AND PISTON RINGS

These Oakite shortcuts speed your metal cleaning

1. Cleaning and rustproofing —*in one washing operation.*

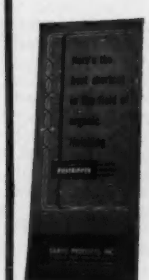


Oakite Composition No. 98 (used cold or hot in one-stage or two-stage washing machines) quickly removes cutting oils and chips and leaves a thin film that protects steel against rusting between operations or during temporary storage.

Excellent for cleaning before inspection: the metal is cool for immediate handling and the film (too thin to affect measurements) prevents finger prints from corroding highly finished surfaces.

One auto manufacturer uses No. 98 in seven plants for cleaning and rustproofing brake cylinders, camshafts, connecting rods, crankshafts, cylinder heads, flywheels, push rods, tappets, wrist pins, etc.

2. Stripping pigmented paints —*with no need for pickling before repainting.*



Oakite Rustripper saves money in paint shops by doing a complete stripping job in one operation. It eliminates extra pickling and neutralizing to remove the metallic pigments, phosphate coatings and rust that prevent successful repainting.

A television manufacturer says "We formerly took 25 minutes to strip rejected cabinets, then had to pickle to remove tarnished phosphate coatings. Today 10 minutes in Rustripper strips the same cabinet so bright and clean you can't tell it from new. Eliminates pickle, neutralize and rinses."

An auto parts maker uses Rustripper for continuous conveyorline stripping. "Cycle of 1 minute and 50 seconds works like a charm stripping paint and incidental rust from rejects and hooks."

FREE For full information write for booklets: 1. "*For Power Washers—Oakite Composition No. 98*" or 2. "*Here's the best shortcut in the field of organic finishing*".

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OAKITE

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TIMKEN® and The Moto-Mated Way

New TIMKEN® Moto-Mated bearings save space, weight, money

THERE'S a big change in cars. The auto industry spent close to $1 billion to make the new 1957 models faster, lower, safer. To meet the big change in cars, the Timken Company launched a whole new concept in bearing design, manufacture and supply in the world's most advanced bearing factory. It's the Moto-Mated Way—mated to your industry's needs.

The Moto-Mated Way anticipates your changing requirements. It puts advanced machines to work for you. Provides you with a better, more uniform product at lower cost. Offers you an almost unlimited source of supply.

From the Moto-Mated Way comes a whole new breed of bearings—Timken® Moto-Mated bearings—in 13 standardized sizes. They're smaller, for more compact design. Lighter, to cut unsprung weight, improve the ride. Capacity-packed, to take the loads of today's power cars. Made with a new high in uniform quality. And they cost less because they're produced by the millions by methods never before seen in the bearing industry.

This year the automotive industry is saving 14.6% on millions of front wheel bearings by adapting to the new sizes. As your use of Timken Moto-Mated bearings grows in new car applications, we can pass along our manufacturing savings to you.

Write us for details on the Moto-Mated Way. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable address: "TIMROSCO".

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